# A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL AND FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE

*Dissertation submitted to*

**M.S. DEGREE-BRANCH - II**

**ORTHOPAEDIC SURGERY**


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# CERTIFICATE

This is to certify that this dissertation titled **"A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL, RADIOLOGICAL & FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE''** is a bonafide record of work done by **DR.N.Nandakumar,** during the period of his Post graduate study from May 2011 to November 2013 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfillment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2014.

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## DECLARATION

*I, Dr.N.Nandakumar, solemnly declare that the dissertation entitled* **"A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL & FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE"** *submitted by me for the degree of M.S.ORTHOPAEDICS (BRANCH-II) is the record work carried out by me during the period of* ***May 2011 to November 2013*** *under the guidance of* ***PROF.V.SINGARAVADIVELU*** **M.S.ORTHO., D.Ortho.,** *Professor of Orthopaedics, Institute of Orthopaedics and traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2014.*

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*p*

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# CONTENTS

# INTRODUCTION

Distal Radius fracture have a Bimodal age distribution[44], among these one with younger age group who sustained injury due to high-energy trauma and another group of elderly patients with relatively low energy trauma.

Due to its high energy association, now most of the distal radius fractures are associated with other long bone fractures. So much of importance is given in treating long bone fracture fixation, and neglecting distal radius fracture which results in poor functional outcome.

The importance of fixation of distal radius fractures evolved over the past two decade from century old treatment of cast immobilization through Kirschner wire fixation to internal fixation with various plates. After tremendous improvement in functional outcome of wrist had been observed following fixation of intraarticular fractures with diverse available volar locking plates and also improvement in surgical technique leading to less disfigurement. Most of the distal ulna fractures will fall into its anatomical position , if good

anatomical reduction of distal radius is achieved by definitive internal fixation .

The goals of the treatment of distal radius fractures are to restore joint line congruity, joint stability and alignment with minimal soft tissue dissection to allow for early mobilization and establishment of good function, but this early mobilization can be started only after stable internal fixation and not by mere K wire fixation. Some studies have revealed that even after better fixation of distal radius fractures alone ,when medial column is not addressed resulted in distal radio ulnar joint instability and hence poor functional outcome at later years.

Good functional results were reported with either modality in low energy fractures in elderly but the ideal treatment for high energy injuries with comminuted distal radius fractures is still being debated. This justifies a separate review on internal fixation of distal radius fractures.

# AIM OF THE STUDY

To analyse the "**Short Term Analysis Of Clinical,Radiological & Functional Outcome Of Surgical Management Of Type B & Type C Distal Radius Fracture With Volar Locking Plate"** done in our Institute of Orthopaedics and Traumatology, Madras medical College and Rajiv Gandhi Government General Hospital between the period of May 2011 and November 2013.

# HISTORICAL REVIEW

Distal radius fracture have been studied very extensively in various literature for two centuries and above. As early in eighteenth century Hippocrates diagnosed wrist fracture by looking at its deformity following injury ,signs like crepitus, paradoxical mobility, edema etc.

A French surgeon named **Pouteau**[2], at the end of 18th century made clear that they were almost always mistakenly diagnosed as wrist dislocations, when there is fracture in reality .

| Name | Nationality | Period | Contribution |
|---|---|---|---|
| Pouteau | French | 18th cent | Wrist dislocation |
| Abramham colles | Irish | 1814 | First to Describe the dorsal displacement |
| Dupuytren | French | 1834 | Dorsal displacement |
| Barton | USA | 1838 | Coronal split of fragment |
| Smith | Irish | 1847 | Anterior displacement |

An Irish surgeon named **Abraham colles**[3] in 1814 described the dorsally displaced distal radius fracture that bears his name. He stated "that the limb will at some remote period again enjoy perfect freedom in all of its motions and be completely exempt from pain but the deformity however, will remain undiminished through life".

A French surgeon named **Dupuytren**[1]in 1834, based on numerous post mortem in dorsally displaced deformed wrist , proved that the majority of the injuries in doubt were actually fractures.

**Then Barton** from USA[5] in 1838 named coronal split of distal radius by implementation of force when the hand is at volar flexion, with fracture line passing intraarticularly in oblique direction, which results in separate volar intraarticular fragment.

An Irish surgeon named **Smith** in 1847[4] described fracture with anterior displacement of distal fragment instead of posterior and was named after him. Closed manipulation reduction technique for distal radius fracture by **Jones (1915)**[6].

**An US surgeon named Connolly in 1995**[8] reduced the fractures by reversing the original mechanism of injury.

Principles of ligamentotaxis and its usage in distal radius fractures by **Anderson and O'Niel (1944)**[21.]

Cast immobilization give stability by its 3point contact was described by **Charnley et al in 1950**[9] . The three points were dorsal, radial and volarly over the distal radius of the fractured fragment.

| Name | Nationality | Period | Contribution |
|---|---|---|---|
| Jones | USA | 1915 | Closed reduction |
| Charnley | UK | 1950 | 3 point contact in cast application |
| Anderson | USA | 1944 | Principles of Ligamento- taxis |
| Connolly | | 1955 | Reduction technique |
| Lambotte | | 1964 | Pinning for Radial styloid |
| Ellis | French | 1965 | T shaped plate |

Pinning of radial styloid for maintaining its reduction was proposed by **Lambotte in 1964**[12.]

Open reduction and internal fixation with T shaped plate for unstable Smith's or volar Barton fracture , which was devised by **Ellis in 1965.**

Volar translation of the hand brings back volar tiltin reduction maneuver by **Agee (1993**)[21]

**Frykman (1967)**[17] was the one first to describe distal ulna fractures associated with distal radius fractures. He classify according to the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture. He established an eponymous classification which is based on the fracture pattern either intraarticular or extra-articular.

Classification which differentiate four components of the radiocarpal joint and five patterns in intra articular fractures was proposed by **Melone (1984)** [21.]

In case of distal radioulnar joint involvement **Sarmiento and associates (1975)**[10] recommended plaster immobilization in supination.

Two pin intrafocal pinning for DRUJ & creation of pseudo joint in distal ulna by **Kapandji in 1976**[13] described the bending mechanism and its relation to theFracture pattern description of the distal radius based on its bending mechanism by **Weber in 1987**[11].

| Name | Period | Contribution |
|---|---|---|
| Frykman | 1967 | First described distal ulna # |
| Melone | 1984 | Four components of RC joints |
| Sarmiento | | Immobilization in supination if DRUJ |
| Weber | 1987 | Bending mechanism |
| Rayhack | 1989 | Radio ulnar wiring for DRUJ |
| Bradway | 1989 | First todo Internal fixation |

Malunited distal radius fracture management using Radio ulnar wiring by **John M. Rayhack in 1989 - 1991**[14] after osteotomising & immobilize the DRUJ , supplementing the ligamentotaxis.

Conclusion given by **John k.Bradway (1989)**[13] that Internal fixation is the treatment of choice for displaced, comminuted intra articular fractures based on its retroseptive study.

Restoration of palmar tilt will not be accurate due to thick palmar ligaments as compared to dorsal ligaments- **Bartosh and Saldana in 1990**[15] .

Biomechanical study in cadaver reveals that primary repair of displaced ulnar styloid avulsion fractures is essential for a stable distal radio ulnar joint- **James shaw et al in 1990**[38].

Essential of postero-anterior and lateral view x-rays was stressed by **Metz and Gilula in 1993**[22] .

Three column concept of the wrist was described by **Rikkli et al in 1996**[16] . He also states that the ulnar column serves as an axis of rotation for forearm.

Functional and radiological outcomes of open reduction and internal fixation of distal radius fracture is largely determined by its type- **Louis W. Catalano III, et al. (1997)**[24]

Restoration of normal alignment and stability of fixation are the main advantages of internal fixation with plates with intra-articular fractures of the distal radius treated with buttress plates.- **Fitoussi F, et al. (1997)**[25]

A new method of internal fixation of unstable distal radius fractures using an anatomically pre shaped, rigid dorsal low profile

plate by **Carter PR, et a1. (1998)**[26] . He also stated ,that autogenous bone graft was plugged in the recessed screw holes.

Double plating method with 2 mm titanium plates, was recommended by **Jakob M, et al.(2000)**[27] for dorsally displaced fractures, where open reduction is indicated to restore congruency and extraarticular anatomy.

Ulnar styloid fractures with significant displacement, along with distal radius fractures posed increased risk of distalradioulnar joint instability by **Megan et al (2002)**[31.]

Articular displacements of distal radius fractures and stated that current operative indications of distal radioulnar joint step or gap deformities greater than l-2mm By **Louis W.Catalano, et al.(2004)**[28.]

Acceptable reduction parameters including radial inclination, radial height, palmar tilt and articular incongruity by **Nana AD et al (2005)** [23] are as follows

1. Volar tilt:0-10*
2. Radial inclination:>15
3. Ulnar variance :1-2mm

4. Step off articular surface : <2mm
5. Less than 5mm shortening compared to opposite DRUJ congruent.

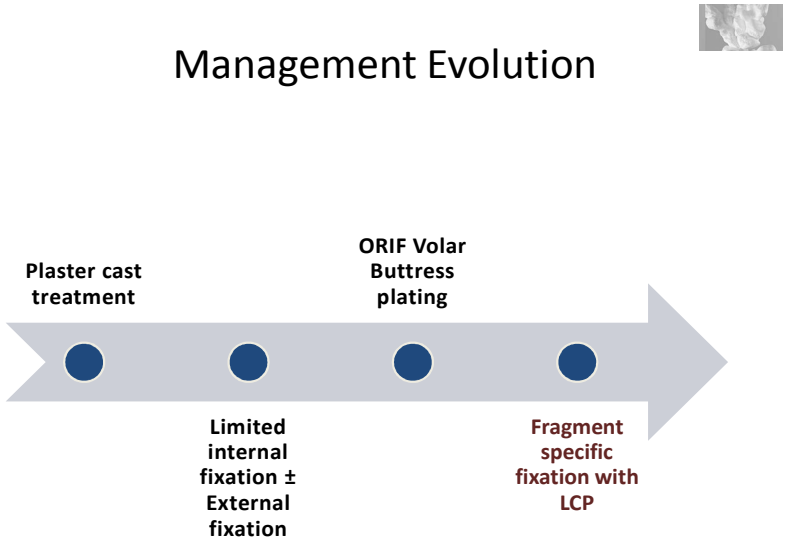
Internal fixation with 2.4 mm locking compression plate and claimed superior stability with maximum number of screws in metaphyseal segment by **Rohit Arora et al (2007)**[30.]

Triangular fibrocartilage complex (TFCC), further stability to distal radio ulnar joint is provided by pronator quadratus, extensor carpi ulnaris,& joint capsule by **Szabo (2006)**[18].

| **Nana AD et al** | **2005** | **Acceptable Radiological parameters** |
|---|---|---|
| Walz | 2006 | Distal ulna fixation |
| Haugstvedt | 2006 | Ulnar attachment of TFCC |
| Schnall stephen | 2006 | Fracture specific implants |
| Rohit Arora | 2007 | Introduction of 2.4mm locking plate |
| Dennison DG | 2007 | Locked plate for Radius |

Internal fixation with fracture specific implants and stated that they provided stable fixation by **Schnall Stephen B et al (2006)**[29 .]

Open reduction and internal locked plate fixation of distal radius fracture gave good to excellent functional outcome score by **Dennison DG in 2007**[37].



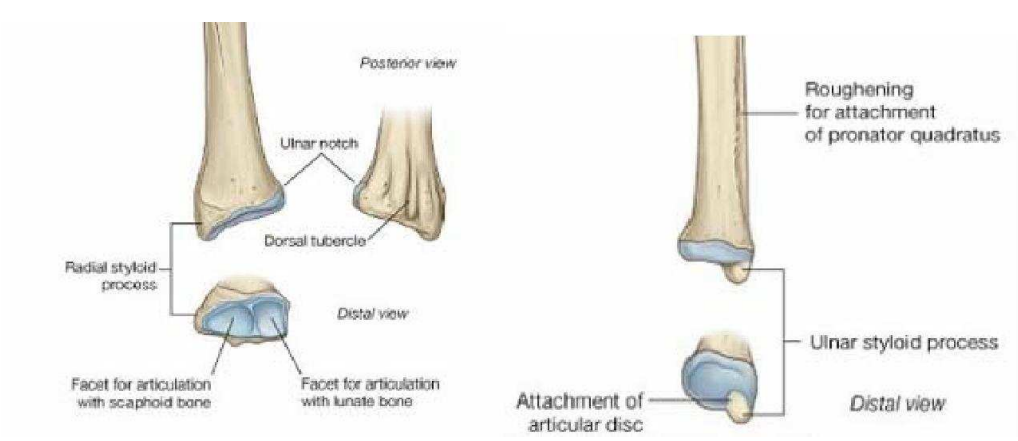
# APPLIED ANATOMY

The word wrist is derived from the word ‘WRAESTON’ meaning to twist. The wrist joint proper includes distal 4-5cms of radius, distal ulna and proximal row of carpus. It encompasses radio carpal joint, ulno carpal joint and distal radio ulnar joint.

**Skeletal anatomy:**

The distal radius consists of the (a) metaphysis, (b) scaphoid facet, (c) lunate facet and (d) sigmoid notch. The distal articular surface of the radius is concave in both the sagital and coronal planes, and is normally declined 10 - 15º palmarly and 15 - 25º ulnarly. There are two fossae or facets that articulate with the proximal surfaces of the scaphoid and lunate. The scaphoid fossa is triangular pointing radially, and is larger than the more quadrangular lunate fossa, located on the ulnar side of the radius. The metaphysis is flared distally in both the AP and the lateral planes with thinner cortical bone lying dorsally and radially. The significance of the thinness of these cortices is that the fractures typically collapse dorsoradially. In addition, the bone with the greatest trabecular density lies in the palmar ulnar cortex. The fact that this bone is thicker even in osteoporotic cadaver specimens may

explain the success of internal fixation techniques, which take advantage of this superior bone. Distally, the radius has a somewhat trapezoidal shape. The radial styloid rotates palmarly 15 degrees off the axis of the radius, which makes capture difficult from a dorsal approach. The strongest bone is found under the lunate facet of the radius. The line of force passes down the long finger axis through the capitolunate articulation and contacts the radius at this location[41]. The palmar ulnar corner is often referred to as the keystone of the radius. It serves as the attachment for the palmar distal radioulnar ligaments and also for the stout radiolunate ligament.




**Skeletal anatomy of distal radius and distal ulna**

The distal ulna consists of ulnar head and styloid process. The ulnar head is the distal end of the ulna articulating with the sigmoid notch of the distal radius. The ulnar head acts as the pivot around

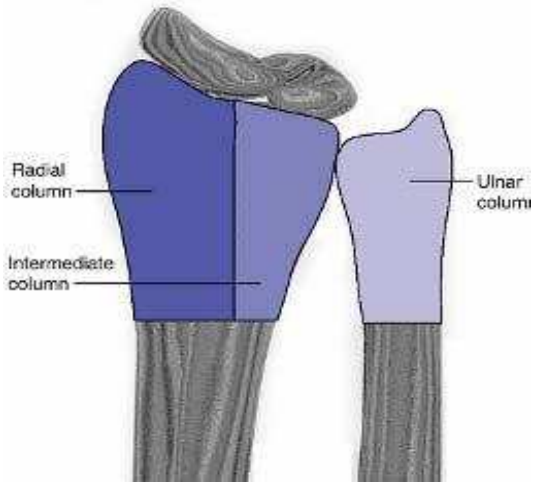
which the distal radius rotates during the rotational movements of the forearm. The ulnar styloid is another important element of the bony anatomy of the DRUJ. It is a continuation of the subcutaneous ridge of the ulnar shaft and stands as a strut on the end of the ulna to stabilize the ulnar soft tissues of the wrist. The sheath of the extensor carpi ulnaris, the ulnocarpal ligaments: ulno lunate, ulnotriquetral, ulnocapitate ligaments, and the triangular fibrocartilage all attach to the distal ulna and help maintain the congruency of the DRUJ; most of these attachments are at the base of the ulnar styloid.

Rikkli et al proposed the three column concept of the wrist, each of which is subjected to different forces and must be addressed as discrete elements[16]. The radial column consists of the scaphoid fossa and the radial styloid. Due to the radial inclination of 22 degrees, impaction of the scaphoid on the articular surface results in a shear moment on the radial styloid causing failure laterally at the radial cortex. The radial column, therefore, is best stabilized by buttressing the lateral cortex.

The intermediate column consists of the lunate fossa and the sigmoid notch of the radius. The intermediate column is the keystone of the radius in maintaining the articular congruity and the function of

the distal radioulnar joint. Failure of the intermediate column occurs as a result of impaction of the lunate on the articular surface with dorsal comminution. A direct buttress of the medial aspect of the radius stabilizes the column.

The ulnar column consists of the ulna styloid, but also should include the TFCC and the ulnocarpal ligaments. Significant forces of around 50% are transmitted across the ulnar column, especially while making a tight fist[16,38].




**Three columns of the distal radius and ulna**

## LIGAMENTOUS ANATOMY

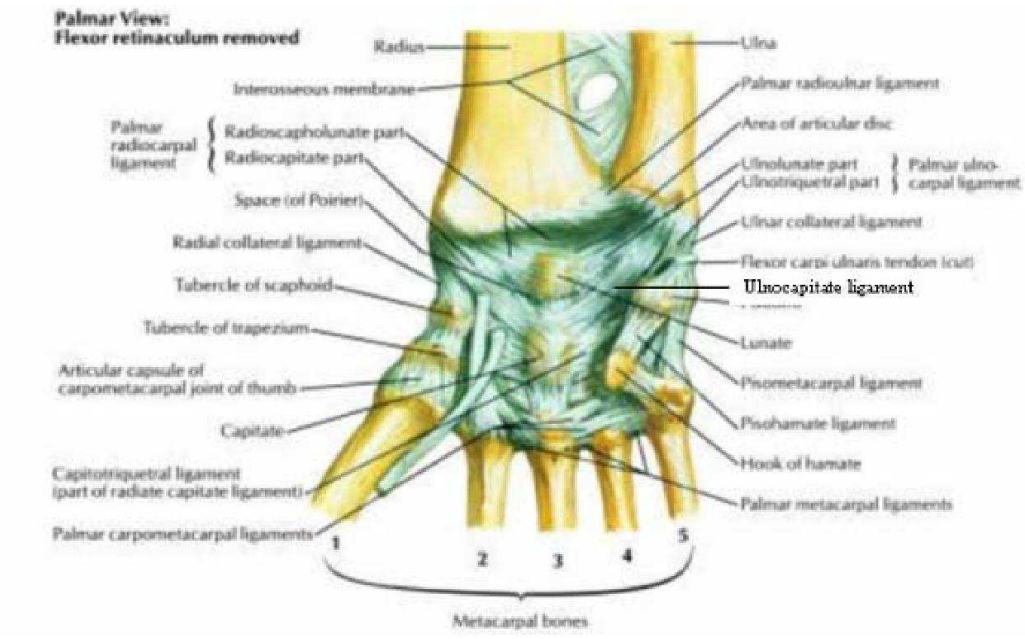
The extrinsic ligaments of the wrist play a major role in the use of indirect reduction techniques. The palmar extrinsic ligaments are attached to the distal radius, and these ligaments are relied on to reduce the components of a fracture using closed methods. There are two factors about these ligaments that make them significant for reduction.

First, the orientation ofthe extrinsic ligaments from the radial styloid is oblique relative to the more vertical orientation of the ligaments attached to the lunate facet[15].

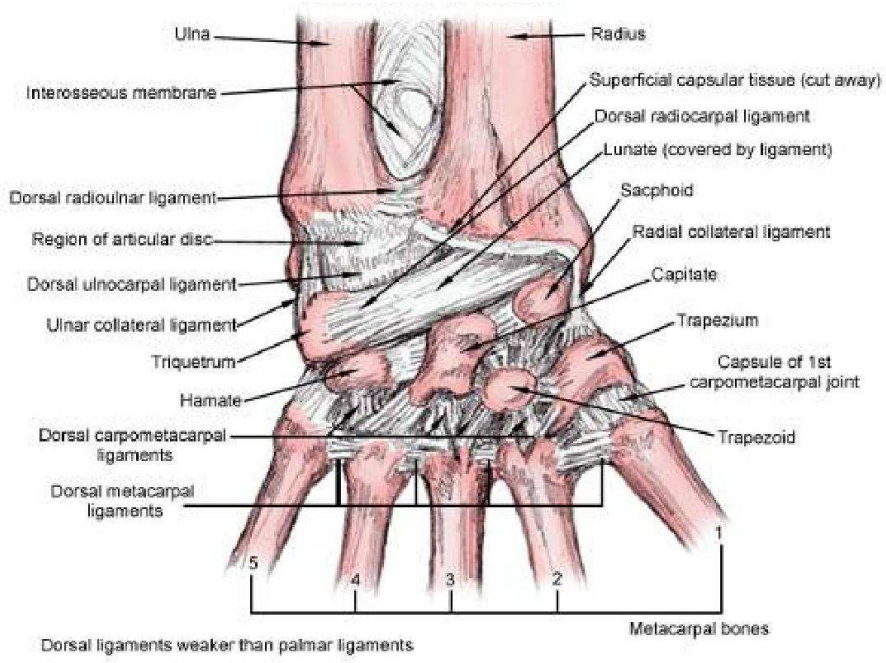
The second significance of the ligamentous anatomy is due to the relative strengths of the thicker palmar ligaments when compared with the thinner dorsal ligaments. In addition, the dorsal ligaments are aligned in Z manner, which makes them lengthen at lesser force than the palmar ligaments. The significance is that distraction will result in the palmar ligaments becoming taut before the dorsal ligaments. Thus, the palmar cortex is brought out to length before the dorsal cortex. It is for this reason that it is difficult to achieve reduction of the normal 12 degrees of palmar tilt using distraction alone[15].

The ulnotriquetral, ulnocapitate and ulnolunate ligaments also are considered part of the TFCC. They share a common origin from the region of the ulnar styloid base and fan out past the triangular fibrocartilage to insert on the triquetrum, capitate and lunate, respectively. The ligaments are important stabilizers of the ulnar corner of the wrist and resist palmar and ulnar displacement of the carpus, particularly in power grip[34,38].

# LIGAMENTS OF THE WRIST

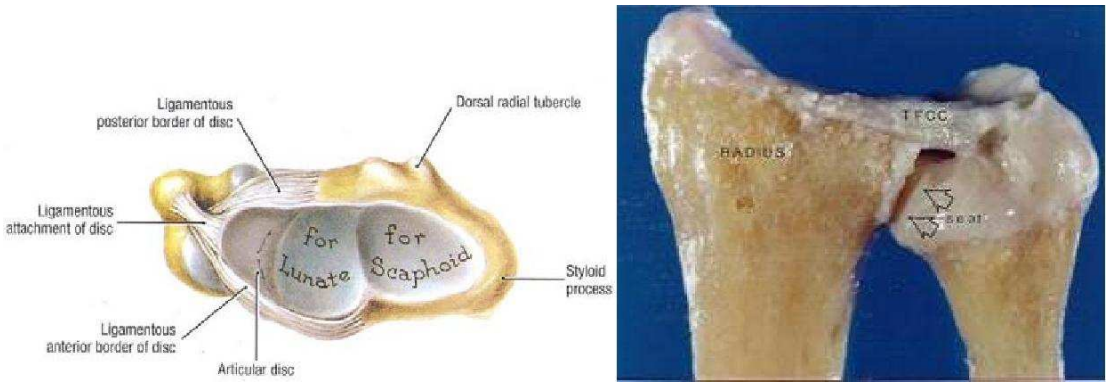



**Anterior (palmar) view**



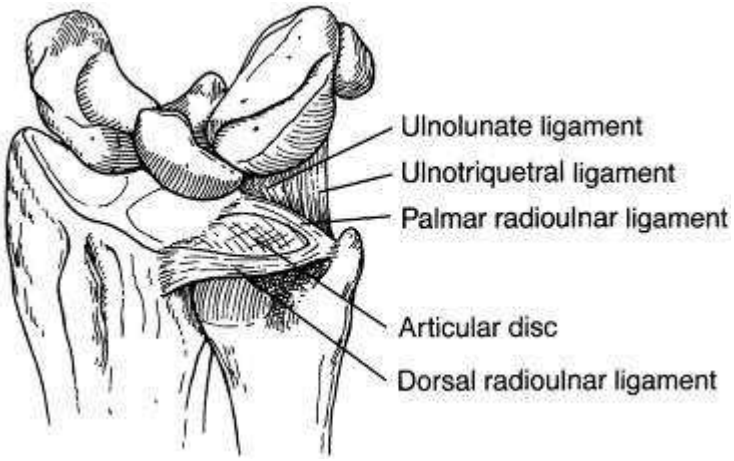
## Posterior (Dorsal) view

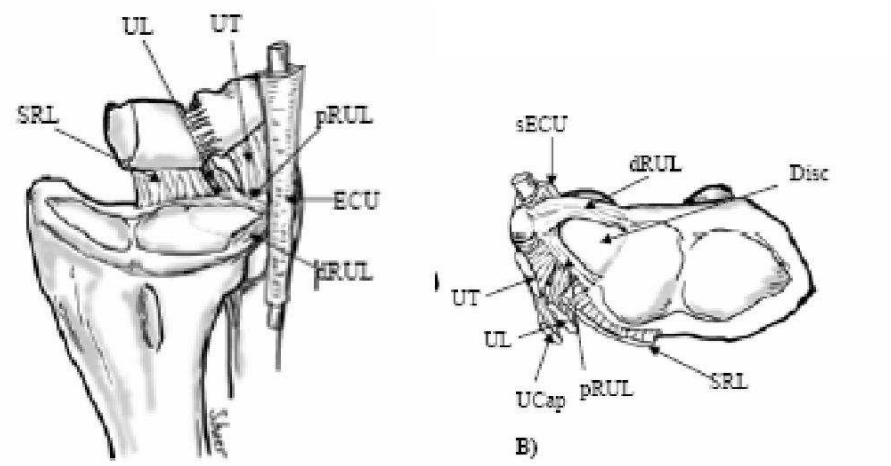
One of the most important structures is the triangular fibrocartilage complex (TFCC), a term coined by Palmer and Werner. It arises from the ulnar aspect of the lunate fossa of the radius and courses ulnarward to insert into the base of the ulnar styloid. It also flows distally, where it is joined by fibers arising from the ulnar aspect of the ulnar styloid and inserts distally into the triquetrum, hamate, and base of the fifth metacarpal. In the center of the complex is the triangular fibrocartilage (TFC) proper[34]. The periphery of the TFC is thickest, usually measuring 5 mm, and is the portion best suited to bear tensile loads. The rim is well vascularized and therefore has good healing potential.




**Triangular fibro cartilage and its components**

## Triangular Fibro cartilage Complex and its components




- UL- Ulnolunate ligament
- UT- Ulnotriquetral ligament
- pRUL & dRUL – Radioulnar ligament
- UCap – Ulnocapitate ligament
- ECU- Extensor carpi ulnaris

## MUSCULAR ANATOMY

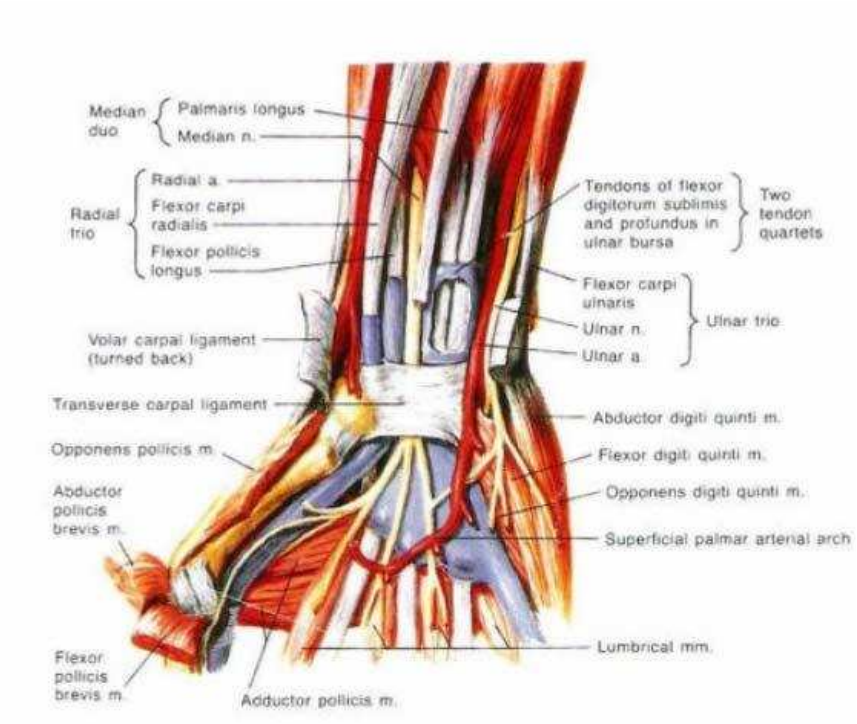
The muscles of importance in the distal end of radius are pronator quadratus and extensor carpi ulnaris which are the two dynamic stabilizers of the distal ulna. The pronator quadratus has a superficial head, which is a prime mover for forearm pronation, and a deep head, which helps stabilize the DRUJ. The pronator quadratus actively stabilizes the joint by coapting the ulnar head in the sigmoid notch, particularly in pronation, and passively stabilizes the joint by viscoelastic forces in supination.

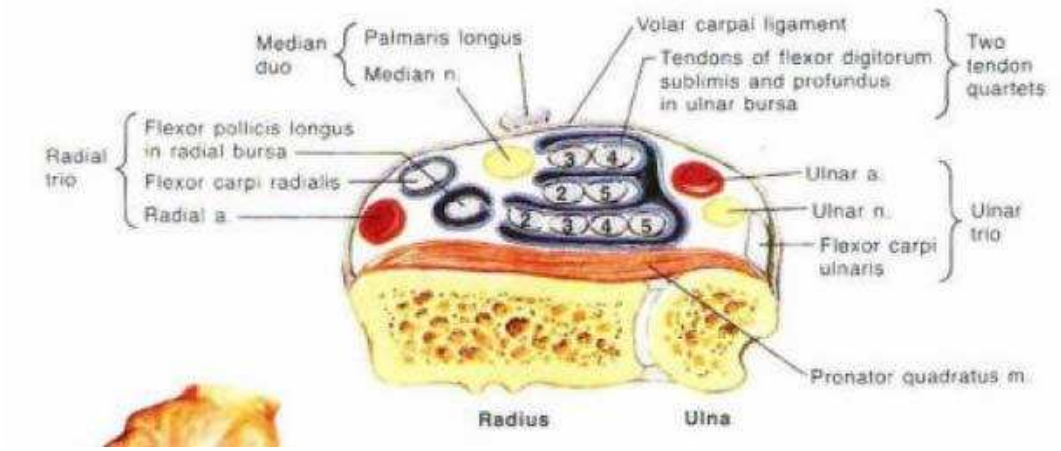
The ECU musculotendinous unit has unique features that lend additional stability to the DRUJ complex. Spinner and Kaplan[39] and Taleisnik et al demonstrated how the ECU is maintained in its position over the dorsal distal ulna by a separate fibroosseous tunnel deep to and separate from the extensor retinaculum and its significance in distal radioulnar stability by the bowstring effect. Brachioradialis is inserted into the radial styloid raising concern in comminuted fractures where radial styloid is seen as a separate fragment.

The flexor tendons related to the anterior aspect of the distal radius are flexor carpi radialis, Palmaris longus, individual tendons of flexor digitorum superficialis and profundus.

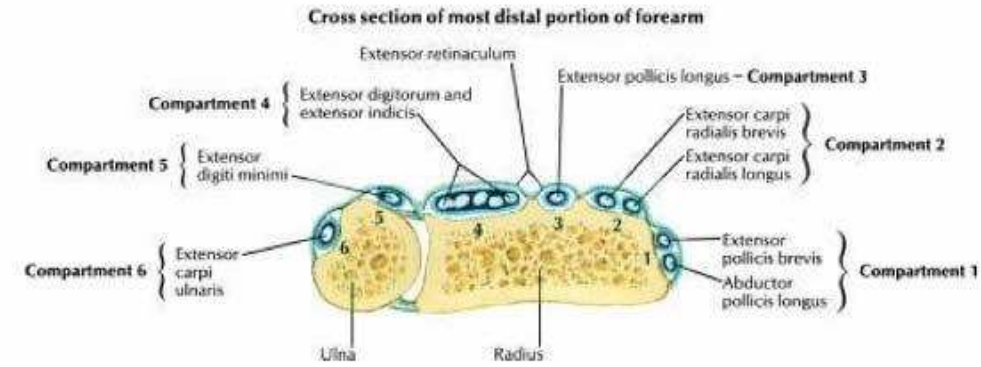
The other extensor tendons on the dorsal aspect of the distal radius are abductor pollicis longus, extensor pollicis brevis, extensor carpi radialis brevis and longus, extensor pollicis longus and extensors to digits and indicis.

**Flexor Tendons, Arteries and Nerves at Wrist**





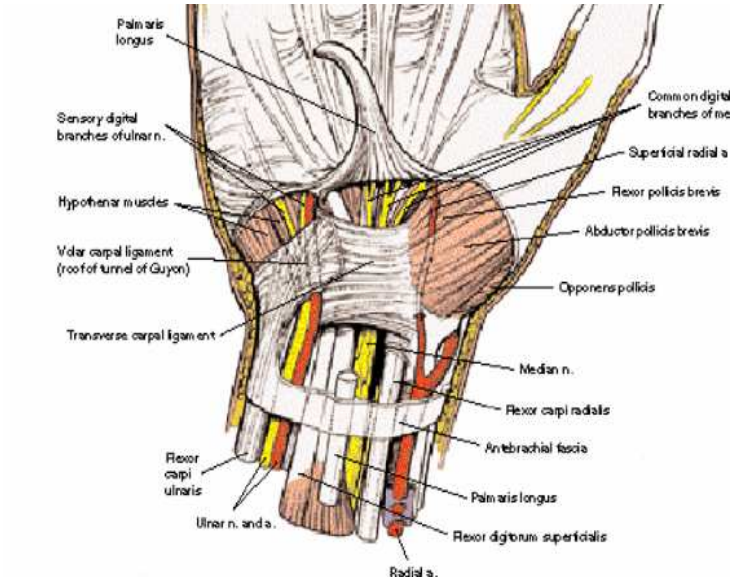

**Anterior relations to the Distal Radius and Ulna**




**Posterior relations to the Distal Radius and Ulna**

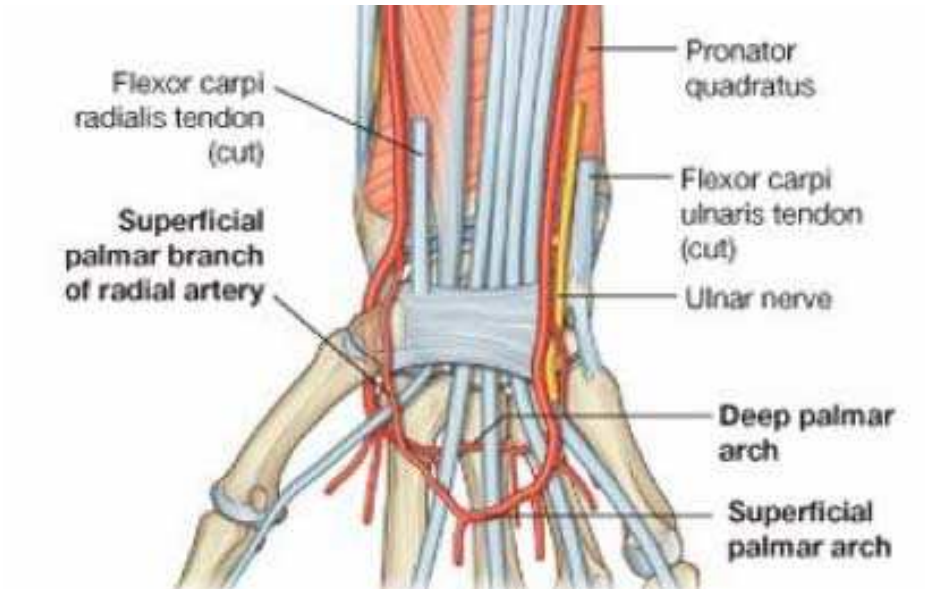
## NEURO VASCULAR ANATOMY

The radial artery lies in the anterior compartment between the brachioradialis & the pronator teres in the proximal forearm after its bifurcation at elbow just medial to biceps tendon, in the lower 1/3 forearm & wrist it lies in between brachioradialis & flexor carpi radialis.




The artery lies over the bed formed by pronator quadratus muscle at the distal end of the radius. It leaves the forearm by winding lateral to wrist and terminates into superficial branch & dorsal deep branch. Radial pulse is felt by palpating it gently against the underlying pronator quadratus muscle and bone.

The ulnar artery after its bifurcation at the elbow just medial to the biceps tendon , it passes underneath the bicepital aponeurosis and into the deep compartment of forearm.




At the level of wrist it lie in between the tendon of flexor digitorum superficialis & flexor carpi ulnaris. It traverses in to the hand through the separate tunnel named Guyon’s canal and continues as superficial palmar arch.

The median nerve becomes more superficial in position at the level of the distal radius, lying between the tendons of the Palmaris longus and flexor carpi radialis muscles. It leaves the forearm and enters the palm of the hand by passing through the carpal tunnel deep

to the flexor retinaculum. The ulnar nerve lies lateral to flexor carpi ulnaris nerve and enter the hand by passing superficial to the flexor retinaculum, medial to ulnar artery and immediately lateral to pisiform bone. The superficial branch of the radial nerve lies on the lateral aspect of the wrist in close association with the brachioradialis tendon.

## MECHANISM OF INJURY

These fractures occur predominantly due to fall on an outstretched hand with shoulder in abduction, elbow in extension & wrist in dorsiflexion. The type of fracture is determined by the rate, the magnitude and the direction of the load is applied to wrist at the time of injury.

The bone quality also determines the fracture pattern to some extent ,which explains the severity of fracture patternin elderly patient even after trivial injury. The oblique angle of the Shearing forces traverses the distal articular surface of the radius by the carpal bones during the fall leads to partial articular fractures.

The shear force injury exerted in particular by lunate to distal radius results in Volar and Dorsal Barton fractures. Eccentric loading of the Scaphoid to the radial column ,results in radial styloid fracture[36]. These types of injury force will not be transmitted to the medial column. Tensile forces exerted by the ligaments & tendinous attachment results in Avulsion type of fractures.

Radial collateral ligament & the brachioradialis attached to the radial styloid will avulse this fragment & also pose difficult to reduce

to its anatomical position,unless these structures are released. These fractures do rarely cause ulnar styloid fractures.

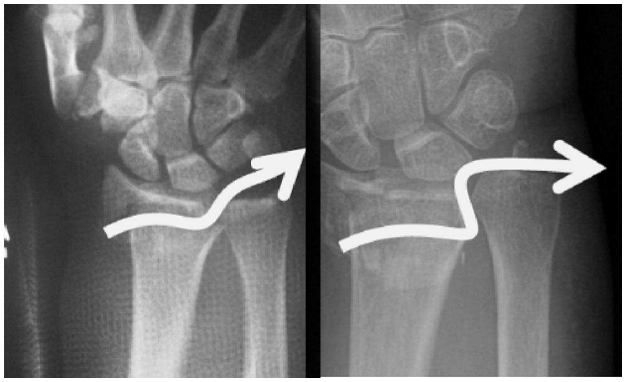
Wrist in 40° to 90° of dorsiflexion in outstretched fall will probably leads to dorsally displaced distal radius fracture[11,17]. Palmar surface fractures first because of tension pull then, followed by compression on the dorsal surface, which explains comminution in dorsal surface. Incurvation theory explains the above mentioned fracture pattern.

Severe comminution of distal radius fractures occur when load is transmitted to the wrist at 60-90* extension , while those at less obtuse angle (20* to 40*) minimal comminution exits[11]. The Intact triangular fibro cartilaginous complex at a higher magnitude of force applied through the wrist in marked wrist dorsiflexion, avulses the ulnar styloid component.

## DRUJ MECHANISMS

Basistyloid fracture of ulna results in TFFC tear , the magnitude of dorsal angulation and displacement leads to extensor carpi ulnaris sheath rupture followed by ulnar syloid tip fracture due to avulsion of ulnotriquetral ligament. If the magnitude of force continues to act at the wrist in extension the palmar ulnocarpal ligaments [ulnotriquetral, ulnolunate and ulnocapitate ligaments] pull exceeds the bowstringing of ECU,which leads to basal fracture of ulnar styloid process starting from the palmar side[18].

Axial loading injuries can lead to impaction of articular fragments. These types of fractures are usually associated with interosseous membrane which results in DRUJ disruption.



**TFCC tear Basistyloid fracture**

# MATERIALS AND METHODS

This study was designed to review the Short Term analysis of clinical, Functional and Radiological outcomes of Surgical Management of Type B & Type c Distal Radius Fracture with Volar Locking Plate**.** From May 2011 to Nov 2013, 28 consecutive fractures of Intraarticular Distal radius in skeletally matured patients were managed primarily by internal fixation with Locking compression plate whose screws are multidirectional. The criteria for patient selection were as follows,

## INCLUSION CRITERIA:

1. Age more than 18 years,
2. AO type B and type C Distal Radius intraarticular fracture associated with or without ulnar styloid fracture,
3. Closed type B & C Distal Radius fractures &
4. Intrarticular Distal Radius fracture with either volar or dorsal displacement.

## EXCLUSION CRITERIA:

1. All undisplaced Extraarticular Radial fracture,
2. All open fractures,
3. Severe osteoporosis with limited functional capacities,
4. Medical co-morbidities &
5. Age less than 18 years.

Patients of both sexes were recruited in the study according to the devised inclusion and exclusion criteria.

## PATIENT EVALUATION

Patients were admitted both in Emergency department and as regular Outpatient Department of those suspected wrist injury. Elucidating history to assess the force & nature of violence , mode of injury, co morbid illness, history of previous surgeries and to rule out head injury or other system involvement. Thorough general examination & evaluation was of the patient as a whole and the limb in specific survey is done.

In case polytrauma due RTA complete skeletal survey including the clavicle, chest, whole spine, pelvis and all long bones was done, otherwise wrist xray alone are ordered. Systemic examination of

cardiac, respiratory, abdominal and neurological functions was done. The upper limb is surveyed for the injuries, to assess the skin condition, Neurovascular status, clinical signs of fracture & its displacement with deformity . Radial and Ulnar artery pulses are checked & compared with other hand. Peripheral Nerve examination is carried out with particular importance to Median nerve considering its close proximity to fracture in volar compartment of forearm. This explains its propensity to cause compartment syndrome. Those patients who belong to our inclusion criteria were subjected to further radiological evaluation.

## RADIOLOGICAL EVALUATION

Standard posteroanterior and lateral views were taken to assess fracture pattern and to assess the parameters . If necessary oblique views were also taken. The fracture pattern are assessed as follows,

1. Palmar tilt,
2. Radial length,
3. Radial inclination
4. Fracture displacement
5. Scapho Lunate Angle,
6. Radio Ulnar index,

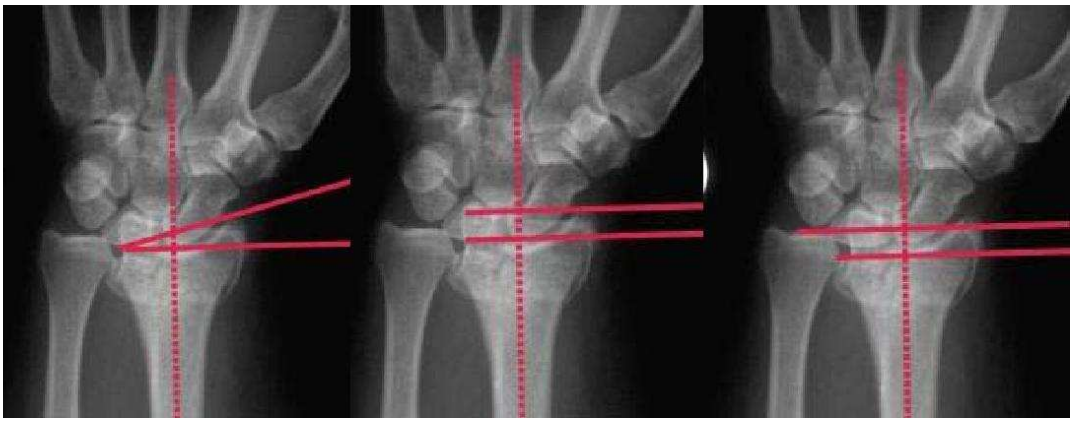
7. Intra-articular step off,

8. Ulnar Angulation ,

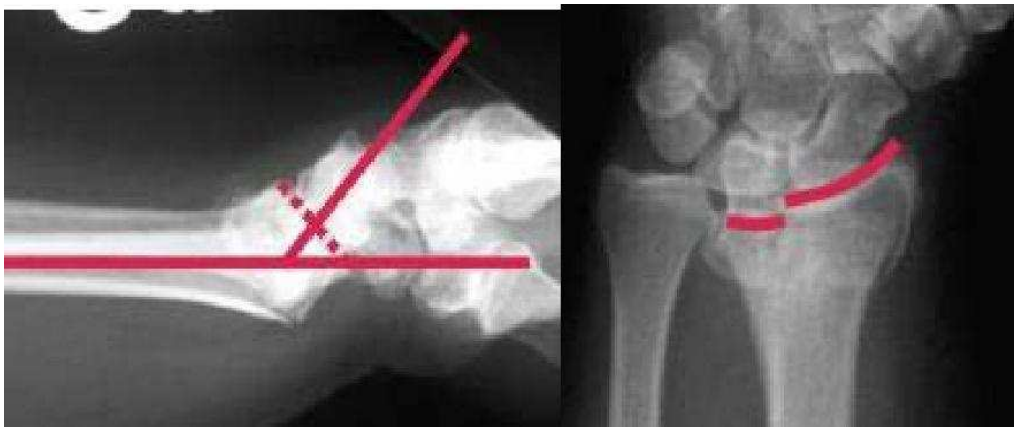
9. Volar Angulation,

10. Grade of Osteoarthosis and

11. Involvement of radiocarpal and distal radio ulnar joints.



**Radial inclination** **Radial height** **Ulnar variance**



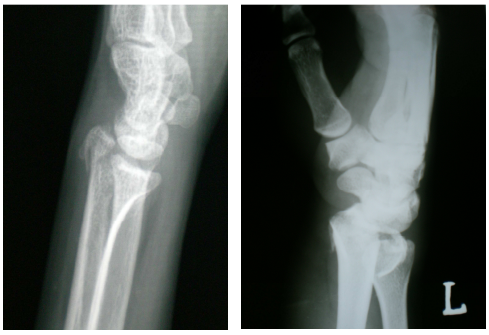
**1. Radial inclination –** This angle is formed between the two lines,first line drawn along the distal radial articular surface and

another line drawn at right angles axis of the radial shaft. Average - 22 degrees (range 15 to 25 degrees).

2. **Radial length –** This is distance between two perpendicular lines drawn to the radial long axis, one at the tip of the radial styloid process and another at the articular surface of radius. Average - 11 mm (8 to 18 mm).

3. **Ulnar variance –** The vertical distance formed between the distal ends of thev radius (medial corner of articular suface) and the lateral corner of the lower end of ulna.

4. **Palmar tilt** – This is measurement of distal radial articular surface tilt in coronal plane .The average is 11 degrees( range 8-14)




**Volar and Dorsal Tilted oblique view**

Lateral view in 40* tilted position was taken with a pad under the hand which makes the radius to incline 22* toward the beam. It eliminates the shadow of the radial styloid and provides a clear

tangential view of the lunate facet in assessing intra articular step off. wrist in oblique view both supination and pronation in 45* also help to clearly visualise the fracture pattern. Ap & lat view Xray taken with the wrist in slight manual traction,which restores the anatomy and reduces overlap.

## COMPUTED TOMOGRAPHY

CT scans have joined the armamentorium of investigations in distal radius fractures. They provide the best assessment of articular surface depression, comminution and displacement. In few numbers of cases with suspicion of severe comminution and displacement CT of Wrist with 3D reconstruction was done.

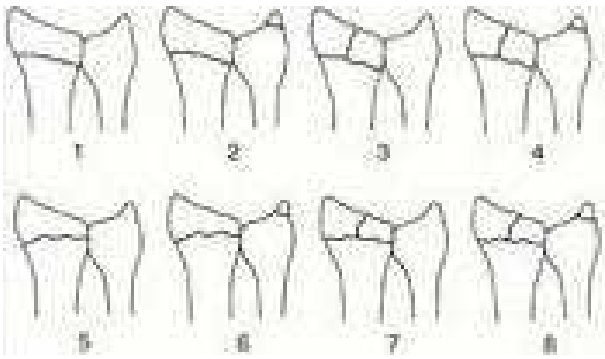
## CLASSIFICATION

Various classifications had been described in the literature for the distal radius fractures.

**F**rykman first described distal ulna fractures associated with distal radius fractures. He established an eponymous classification system[17], which defines the fracture as intra-articular or extra-articular. It also describes the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture.

This system does not quantitatively assess the degree of comminution, shortening and the initial impact. Hence, the prognostic value is low in suggesting a treatment.

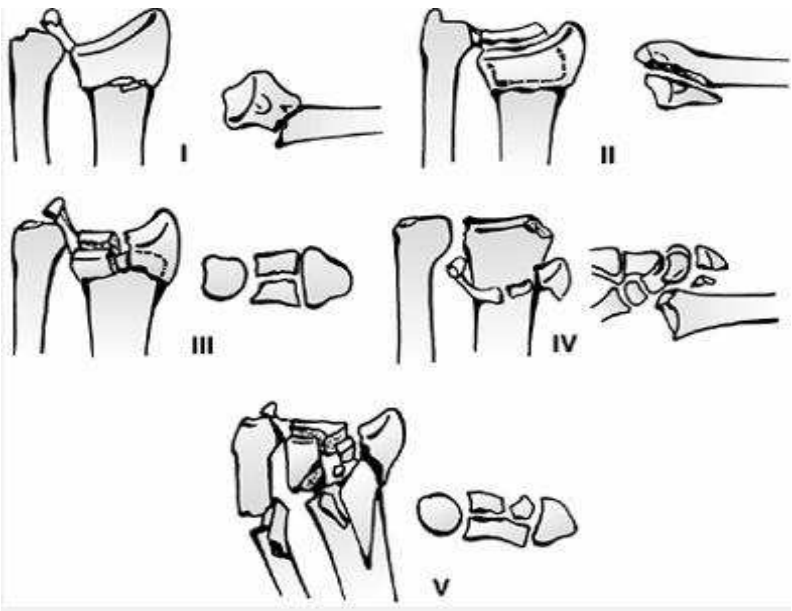
**Frykman classification of Distal Radius fractures**



| Type | Pattern of Fracture |
|---|---|
| I | Radius # Extraarticular |
| II | Both Radius & Ulna Extraarticular |
| III | Intraarticular # of Radiocarpal joint |
| IV | Intraarticular # of Radiocarpal joint + Ulna # |
| V | Intraarticular # of Radioulnar joint |
| VI | Intraarticular # of Radioulnar joint + ulna# |
| VII | Intraarticular # of Radiocarpal & Radioulnar joint |
| VIII | Intraarticular # of Radiocarpal &Radioulnar joint +ulnar # |

Fernandez proposed a mechanism-based classification system that would address the potential for ligamentous injury and thereby assist in treatment recommendations[41].

| Type | Fracture Pattern |
|---|---|
| I | Metaphyseal bending Fracture |
| II | Shearing Fracture-Results in coronal split |
| III | Compression Injury Results in articular fragmentation |
| IV | Avulsion Fracture or Raidocarpal # dislocation |
| V | Combination Injuries |




**Fernandez Classification**

AO Comprehensive Classification for the distal radius and ulna are designated as 23 and is further classified into three types as given below.

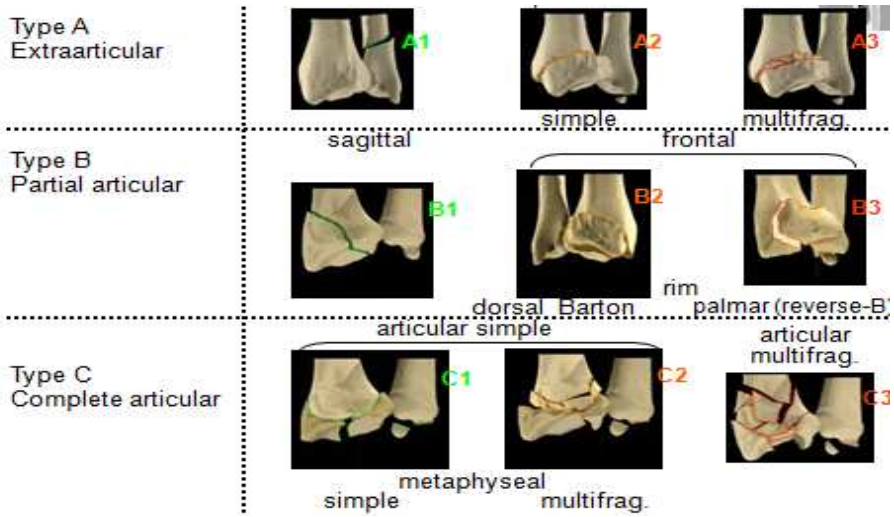
**23 A – Extra-articular Fracture**

A1 – Extra-articular fracture of the ulna, radius intact.

A2 – Extra-articular fracture of the radius, simple and impacted.

A3 - Extra-articular fracture of the radius, multifragmentary.

**AO Classification**




23 B – Partial articular fracture wherein the fractures involve only part of the articular surface, while rest of that surface remains attached to the diaphysis.

| | | |
|---|---|---|
| B1 | – | Partial articular fractures of the radius, sagittal. |
| B2 | – | Partial articular fracture of the radius, dorsal rim (Barton). |
| B3 | – | Partial articular fracture of the radius, volar rim (reverse Barton). |
| 23 C | – | Complete articular fracture, wherein, the articular surface is disrupted and completely separated from the diaphysis. |
| C1 | – | Complete articular fracture of the radius, articular simple, metaphyseal simple. |
| C2 | – | Complete articular fracture of the radius, articular simple, metaphysealmultifragmentary. |
| C3 | – | Complete articular fracture of the radius, multifragmentary. |

**Modified AO Classification**

It is simplified to 5 Intra-articular fractures

| | | |
|---|---|---|
| A | – | Extra-articular, |
| B | – | Partial articular, |
| B1 | : | Radial Styloid, |
| B2 | : | Dorsal rim fractures, |
| B3 | : | Volar rim fractures, |

B4 : Die Punch fractures,

C – Complete articular

The "die-punch" fracture is the only additional subgroup in this classification.

In our study we routinely used AO classification, since it clearly addresses the different fracture patterns, which helps in planning & management.

## PREOPERATIVE WORKUP

The limb was stabilized in an Above Elbow slab temporarily and limb elevated to reduce the pain and swelling. Routine investigations were done to obtain anaesthetic fitness. All patients included in the study were subjected to the described surgical procedure, after evaluating the fracture pattern in detail with trauma series xrays and if necessary CT with 3D reconstruction image.

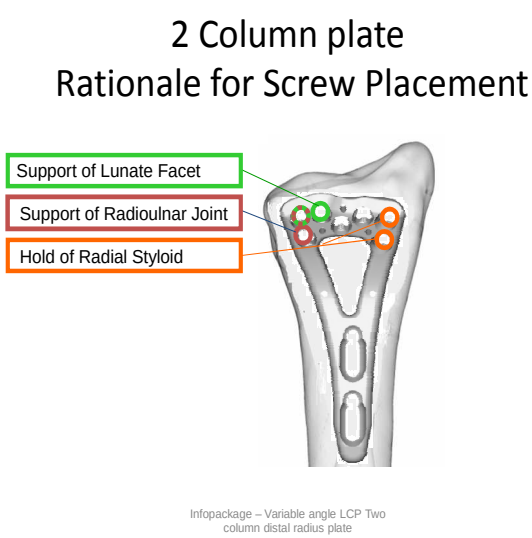
## SURGICAL PROCEDURE

Internal fixations with Volar Locking Plate, were performed in the Institute of Orthopedics and Traumatology in Rajiv Gandhi Govt General Hospital & Madras Medical college, Chennai. All the fractures were Approached by volar approach & fixed with 2.7mm Fixed angle

Volar locking plate with screws in different direction are specially designed to buttress the distal radius.

## PREOPERATIVE PLANNING

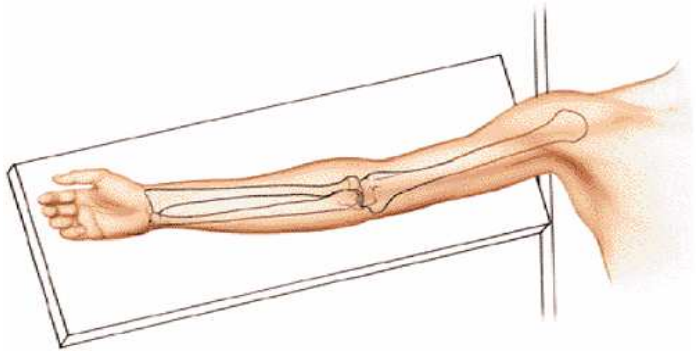
The choice of a particular plane of approach for each case depended on the fracture pattern, reducibility and stability.The armamentorium of plates for distal radius were 2.7 mm Locking compression plate which is anatomically precontured and Kirschner wires were used if there is additional DRUJ .




**Fixed angle 2.7mm volar LCP**

# PATIENT POSITIONING

Patient was positioned supine on the radiolucent table with arm by side .Image intensifier was positioned under the arm-board so as to visualise the distal radius, distal ulna and the articular surface to check the reduction and also for screw placement.

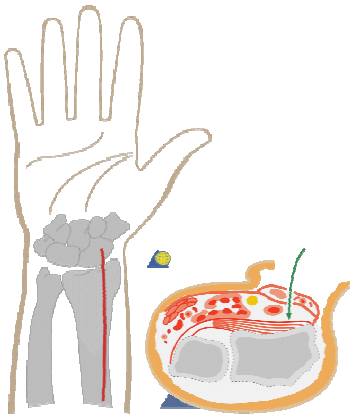


## SURGICAL TECHNIQUE:

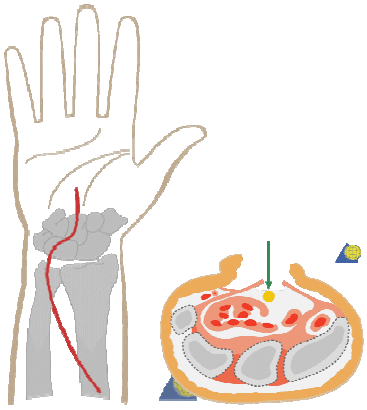
All procedures were performed under general or regional anaesthesia (supraclavicular or interscalene block). Our standard practice was preoperative prophylactic intravenous cefotaxime and usage of diathermy for homeostasis.

# VOLAR

FCR approach



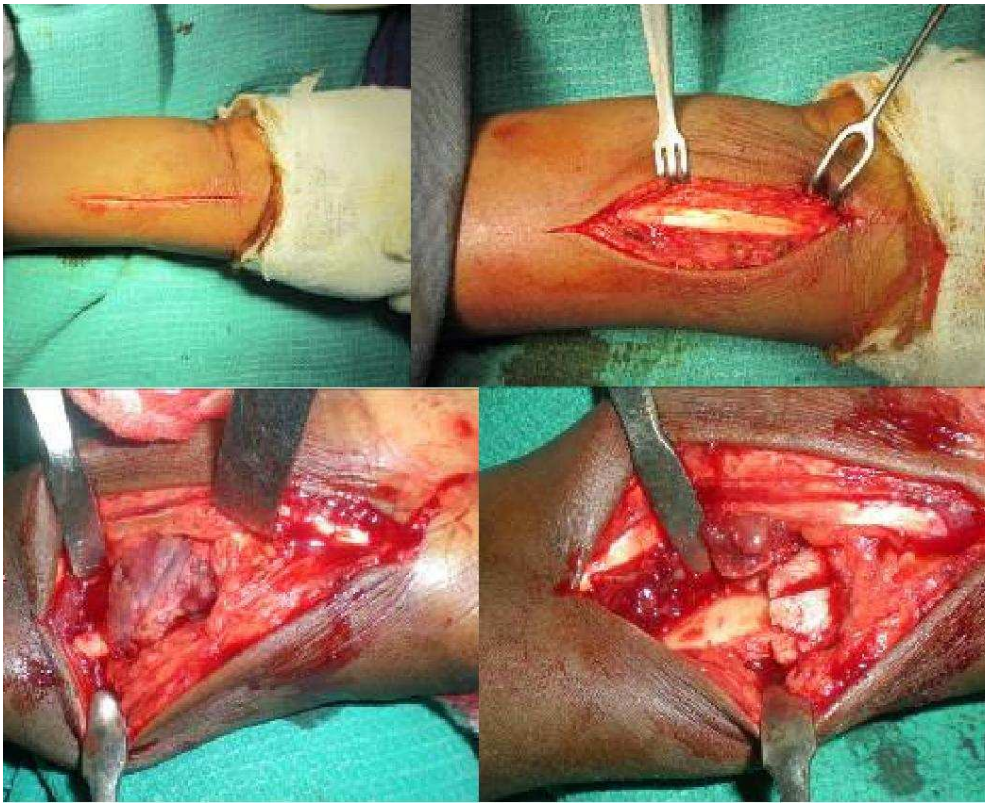
Extended carpal tunnel approach



The standard volar approach named Henry Approach was used in most of the cases to address the distal radius fragments. Skin incision made just medial to radial artery at the wrist level which lies in subcutaneous plane, can be felt .The plane is in-between the radial artery and the flexor carpi radialis. For the intermediate column fragment under the lunate facet, plane between the flexor carpi radialis tendon and the median nerve termed extended volar carpal approach, either of which is used routinely.

The pronator quadratus was erased from its lateral attachment and lifted towards ulnarside.

Intra operative pictures of the Exposure of the Distal Radius



Open reduction was performed using intrafocal leverage, traction, and temporary fixation with Kirschner wires followed by definitive fixation with the implants of choice In cases which had a displaced radial styloid or fragments too small for other means of fixation, was fixed with Kirschner wires and buttressed with Volar Locking Plate.

Open reduction and internal fixation with Locking compression plates with 2.7 mm screws were used in all our study patients, since all are intra-articular fractures with varying degree of comminution. These screws had better purchase in the distal radial comminuted fragment with poor bone stock.

**Intra operative picture of Distal Radius with LCP**

The ulnar styloid was found to be fractured in nine of our study patients. Once the radius and intermediate column is fixed with angle stable volar LCP, the ulnar component align to its original position if there is no DRUJ disruption.

If DRUJ disruption warrants fixation, then it was stabilized with kwire which transfixes radius & ulna. A period of four weeks immobilization in above elbow cast is followed as post operative protocol. Transfixation wires removed after four weeks and wrist mobilization started.

## POSTOP PROTOCOL

All of them started with I.V third generation cephalosporin during induction which was continued for 3 days post operatively then converted into oral antibiotic of 3$^{rd}$ generation cephalosporin of 1 week

The hand and forearm was initially placed in a compressive dressing and elevated for forty-eight to seventy-two hours to reduce swelling. All patients were encouraged to begin an early active range of motion of the wrist and hand as tolerated by patient. The patients who are additionally fixed with Kirschner wire for DRUJ were immobilized with above elbow cast for three weeks based on the bone quality and union they are mobilized after 4 wkees. Sutures were removed on the 12$^{th}$ post-operative day. Patients were not allowed to lift heavy weight for twelve to sixteen weeks but wrist mobilization exercises & hand grip strengthening exercises are vigorously initiated.

# POSTOP RADIOLOGICAL EVALUATION

Both Posteroanterior and lateral views were taken and fracture pattern are assessed by the parameters like palmar tilt, radial height, radial inclination, dorsal deformity & carpal instability. The oblique lateral view was also taken to assess any residual depression of the palmar lunate facet.

**Lindstrom's criteria(Sarmiento's modification)** was followed to evaluate radio logically ,

| **Result** | **Deformity** | **Residual dorsal tilt in Degrees** | **Radial shortening in mm** | **Loss of radial inclination in Degrees** |
|---|---|---|---|---|
| **Excellent** | **No or insignificant** | 0 | < 3 | < 5 |
| **Good** | Slight | 1 – 10 | 3 – 6 | 5 – 9 |
| **Fair** | Moderate | 11 – 14 | 7 – 11 | 10 – 14 |
| **Poor** | Severe | > 14 | > 11 | > 14 |

## FOLLOW UP EVALUATION

All patients were reviewed by a single observer. Clinical assessment included time to return to work, presence of wrist pain, range of motion, loss of alignment and radial height and grip strength using Jamar Dynamometer Radiographs were reviewed monthly for fracture union and to assess fracture alignment. Bony union was defined in both clinical and radiological terms with radiological evidence of bridging trabeculae across the fracture site and disappearance of the fracture line in both posteroanterior and lateral views and clinical evidence of normal activities without pain. The functional outcome of the patients were evaluated with Mayo Wrist Score. During every review the patient were evaluated and score given from 0 to 100.Those who score on and above 90 fall in excellent category & those below 60 are termed poor outcome group. The other two category are good and satisfactory if there scores were 80-90 and 60-80 respectively.

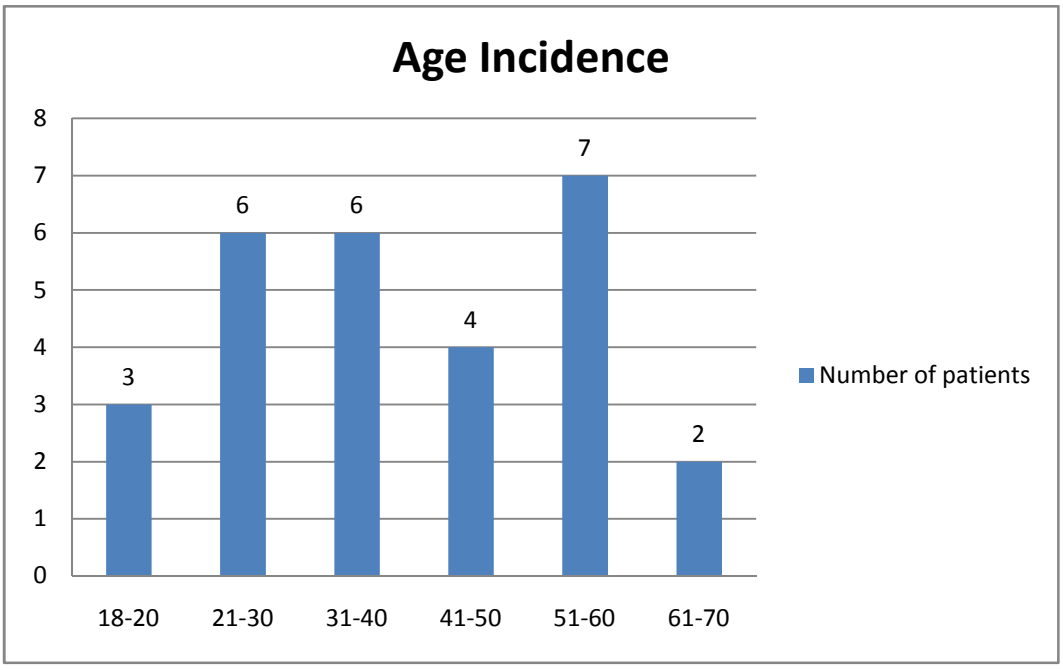
# OBSERVATIONS

The following observations were made in the study are as follows,

## AGE INCIDENCE:

Patients' age ranged from 18 to 70 years. Average: 42.8 yrs

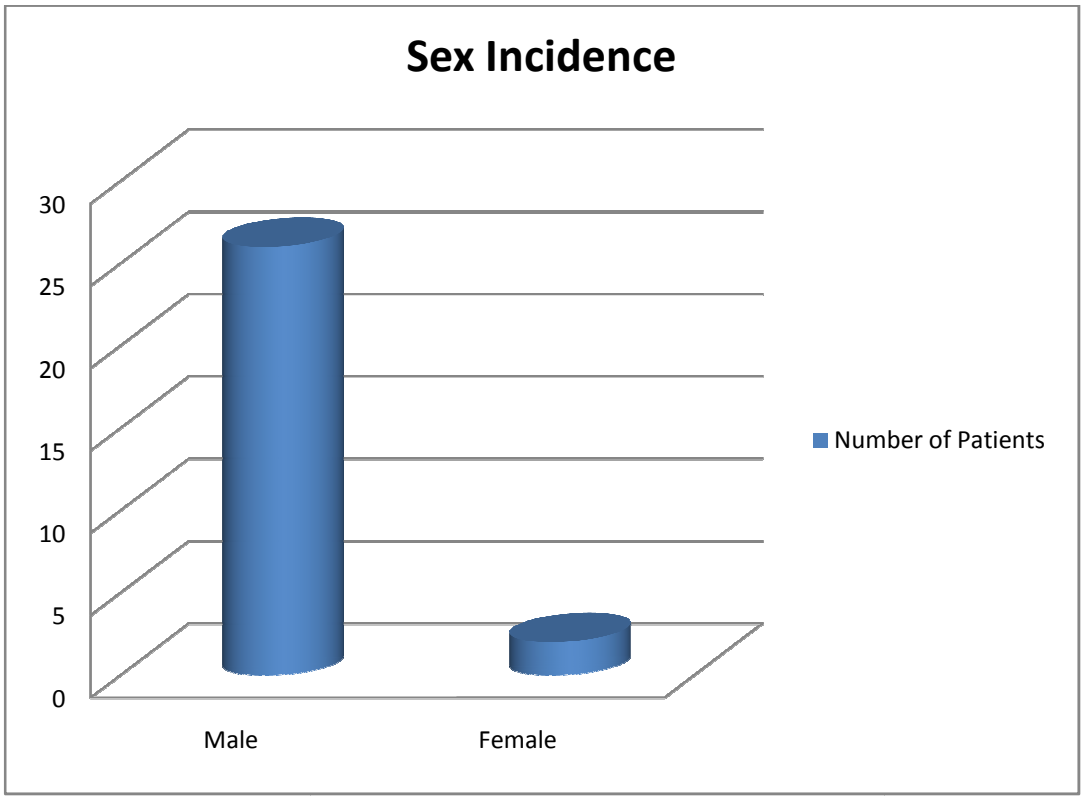
| Age in Years | Number of patients |
|---|---|
| 18-20 | 3 |
| 21-30 | 6 |
| 31-40 | 6 |
| 41-50 | 4 |
| 51-60 | 7 |
| 61-70 | 2 |
| Total no of patients | 28 |



## SEX INCIDENCE

In our series Males predominated with the ratio of 13:1

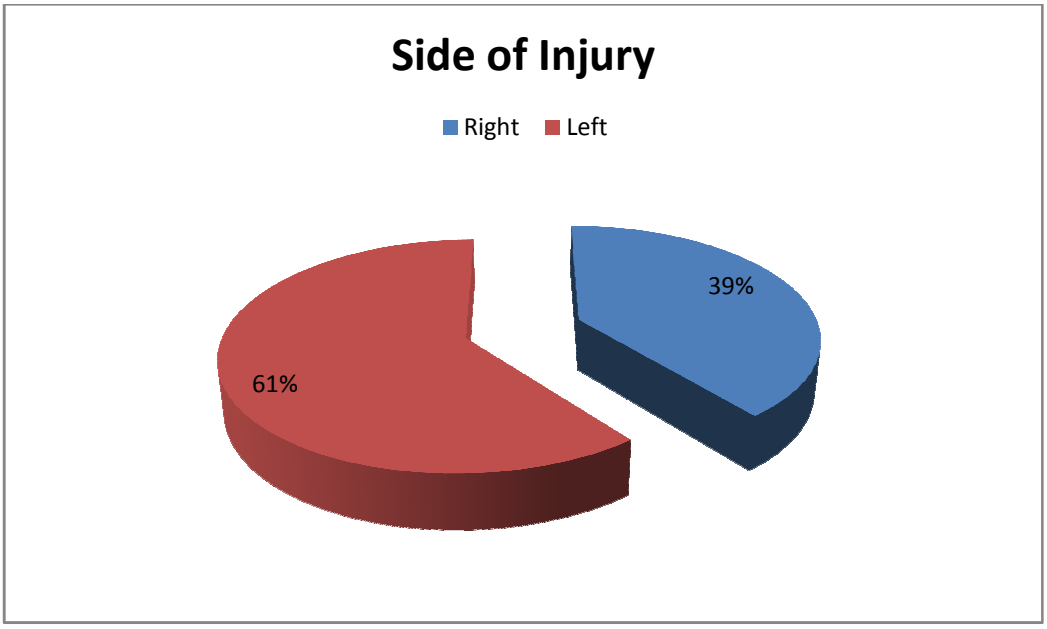
| Sex | Number of Patients |
|---|---|
| Male | 26 |
| Female | 2 |



## SIDE OF INJURY

In our study 17 patients had left sided injury accenting for 60% of the total patients

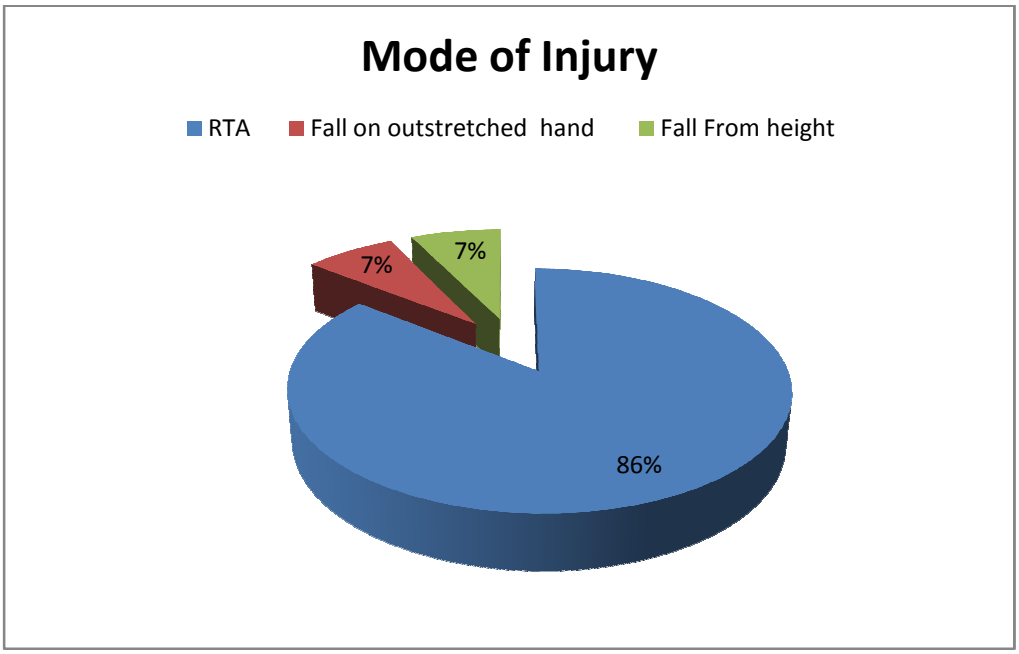
| Side | Number of Patients |
|---|---|
| Right | 11 |
| Left | 17 |



## MODE OF INJURY

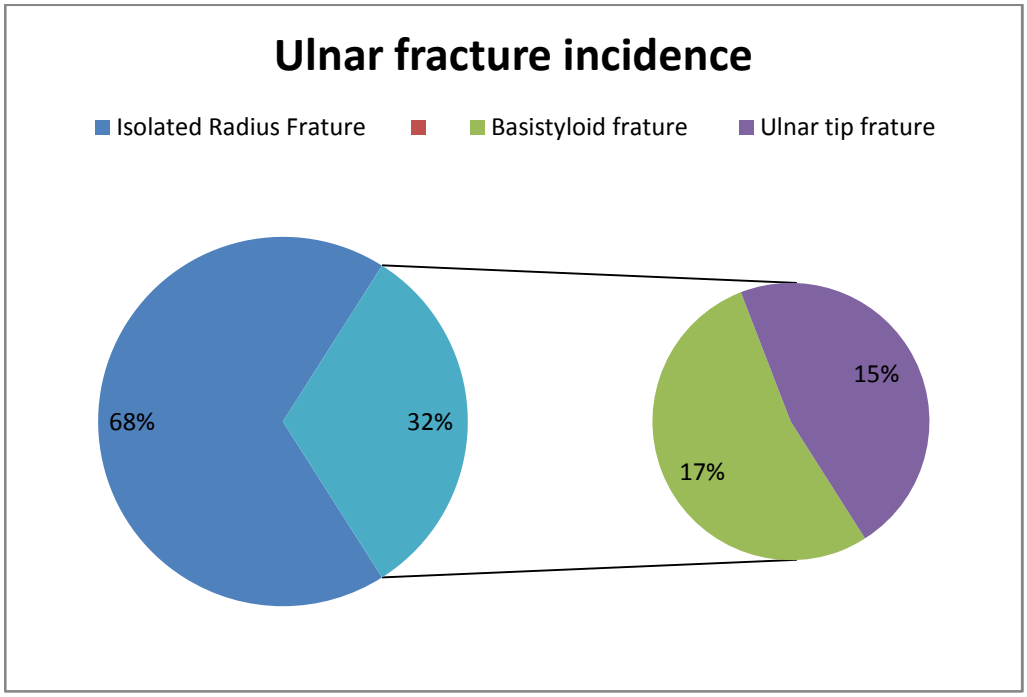
In our series **RTA** was the predominant mode of injury.

| Mode of Injury | Number of Patients |
|---|---|
| RTA | 24 |
| Fall outstretched | 2 |
| Fall from height | 2 |



## Ulnar Styloid Process Fracture

In our series ulnar styloid process was fractured in 9 study patients, of which four belongs to ulnar tip fracture and the remaining five involves the basistyloid fracture.



## FRACTURE CLASSIFICATION

### AO Muller's

| Type | Number of pts |
|---|---|
| B1 | 2 |
| B2 | 2 |
| B3 | 4 |
| C1 | 5 |
| C2 | 7 |
| C3 | 8 |

Muller's type C fractures predominated in our study 71 % of patients, of which C3 account for 40%. 6 of the 28 patients presented with significant co-morbid illness in the form of Diabetes Mellitus or Systemic Hypertension which were adequately controlled prior to surgery.

All patients belonged to lower socioeconomic strata of the society with moderate built and nourishment.

In our study all the pts belongs to closed injury category .Most of the pts (90%) operated with in 3days from the time of injury. Twenty of our patients are poly trauma and associated with other long bone fractures. These patients are stabilized by appropriate Internal/External fixation methods.

Associated with poly trauma explains the severity of violence .The data as follows in our study,

| **Associated injuries** | **Number of patients** |
|---|---|
| # Shaft of femur ipsilateral | 2 |
| # Shaft of femur contralateral | 2 |
| # Both bones Leg ipsilateral | 2 |
| # Tibial Plateau | 2 |
| # L1 | 2 |
| # L3 | 1 |
| C5C6 subluxation without Neurological deficit | 1 |
| # pubic rami | 2 |
| # Olecranon ipsilateral | 1 |
| Crush injury contralateral arm | 1 |

| | |
|---|---|
| Crush injury leg contralateral | 1 |
| # Calcaneum | 2 |
| Compartment syndrome | 1 |
| # Proximal Humerus contralateral | 1 |
| # scaphoid | 2 |

Two of the patients had Head injury for which Neurosurgical intervention is required . Neurovascular status was intact in all the patients under study. The average delay in surgery in our study was 4.4 days and the range was 12 hours to 18 days. Tourniquet was used in two patients and hemostasis was achieved in all patients using diathermy before closing the surgical wound. 19 patients were approached by standard Volar Henrry approach and another 9 by Extended volar carpal approach.

The fractured Ulnar styloid fragment was not fixed in 9 of our study patients . Two patients in our study had DRUJ transfixation by K wire. In two patient radial styloid fragment was fixed with 3.5mm cortical lag screw.

Two patients in our study are treated by external fixator for C3 type # elsewere were presented late to our hospital, also undergone ORIF with volar LCP after removal of ligamentotaxsis.

Average duration of surgery was one hour and 20 minutes with range being 40 minutes to 2 hour. Average loss of blood during the surgery was 100 ml ranging between 50 to 250 ml.

Bone grafting was **not done** in any of the cases in spite of the higher degree of comminution ,because the fragments are well buttressed with volar plate. The reduction of the distal radius and its articular congruity were confirmed with the image intensifier during the fixation and ensured before closure of the surgical wound. Violation of distal row locking screws into the articular joint is avoided by verifying with image intensifier. Drain was used in all our of our patients.

Mobilization of the wrist and the hand were initiated from the $2^{nd}$post-operative day as tolerated by the patient except for those with severe bone loss and with gross intra-articular comminution. Those patients fixed with additional K wires were initially given below elbow cast and was mobilized for 4 weeks.

# RESULTS

The follow up in mean was 6 months, range between 3 months & 18 months. 26 of the 28 patients had regular follow-up. Two patients are lost to follow-up after surgery due to social reasons. Hence only 26 patients were analyzed and the results are as follows,

**UNION:** Good bony union is visualized radio logically in all our study patients. The mean time of union was 12 weeks with a range of 10 to 18 weeks, with 22 pts majority of 84% healed by 12 weeks. Rest of the 4 cases took a longer duration. One case of delayed union was reported. Longer duration to union is noted in patients of with severity of comminution and bone loss.

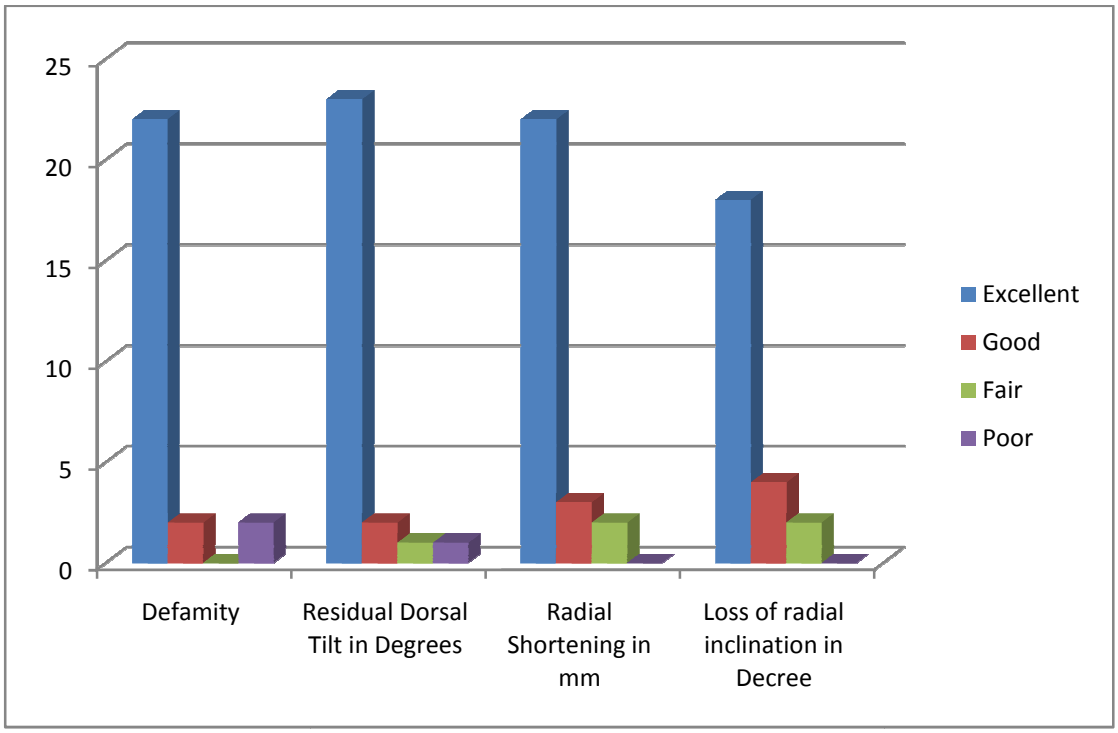
**MALUNION:** Three were 3 instances of loss of reduction with fracture collapse, which resulted in intra-articular violation of screws.

**NON UNION** : Two instances of nonunion of basistyloid ulnar fracture group was reported out of nine patients. The ulnar styloid component was not addressed in our study.

## RADIOLOGICAL OUTCOME

### Sarmiento's modification of Lindstrom's criteria:

| Result | Deformity | Residual dorsal tilt in degrees | Radial shortening in mm | Loss of radial inclination in Degrees | Mean |
|---|---|---|---|---|---|
| **Excellent** | 22(no deformity) | 23 | 22 | 18 | **21.15 (84%)** |
| **Good** | 2 | 2 | 3 | 4 | **2.7 (11%)** |
| **Fair** | - | 1 | 1 | 1 | **1.25 (2%)** |
| **Poor** | 2 | 1 | - | - | **1.5 (3%)** |



84% of patients in our study had excellent radiological outcome score based on Sarmiento's modification of Lindstrom's criteria. 11% had good results and less than 5% had fair or poor results radiologically.

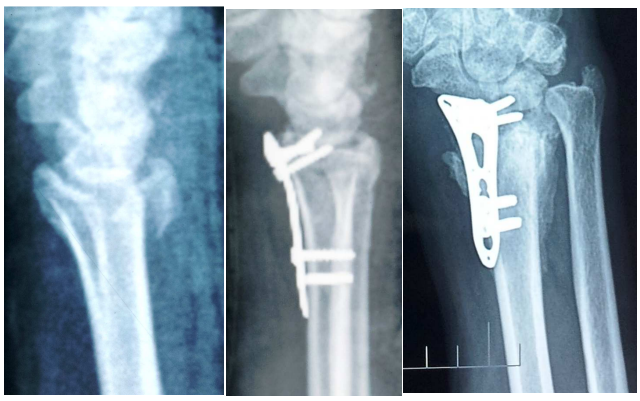

Mean range of motion were palmar flexion 75 degrees (55-90*); Dorsi flexion 60 degrees (55-85*); supination 70 degrees (55-80*); and pronation 65 degrees (45-75*); ulnar deviation 20 degrees (20-35*) and radial deviation 15 degrees (7-23*). Grip strength is assessed using Jamar dynamometer and was on average 80% compared to the opposite normal side with range being 50% to 100%. Rotational movements were on lower side of our observed range in three of our patients who had malunion. Grip strength and range of movements was

found to be less among the group who belong to older people who were relatively less co-operative for the physiotherapy and those who are immobilized in cast for reasonable period of time for those with severe comminution and bone loss.

## COMPLICATIONS

Two of our patients had screws trespassing the articular surface into the wrist joint results in erosion of distal fagment. Two of our patients had prominent wires that were felt subcutaneously on the Radial side. None of the four had any functional disturbance or pain because it was removed after 4 weeks in case of k wire & implant exit was done at 3months in those screws violated into the joint.

Stiffness of the wrist joint and the hand was noted in three patients who were delayed presented to our hospital, initially all these pts are managed conservatively for about 3 weeks which results in difficult in reduction at operating table. Three patients who were immobilized in cast postoperatively due to severe bone loss had transient stiffness which was overcome with aggressive physiotherapy resulting in resonable range of motion thereafter.



In our study one patient had deep infection which warranted wound debridement in the first postoperative week, in followup the comminuted fragments were resorbed which results in disblacement leading to malunion. The infection was controlled by appropriate antibiotics.

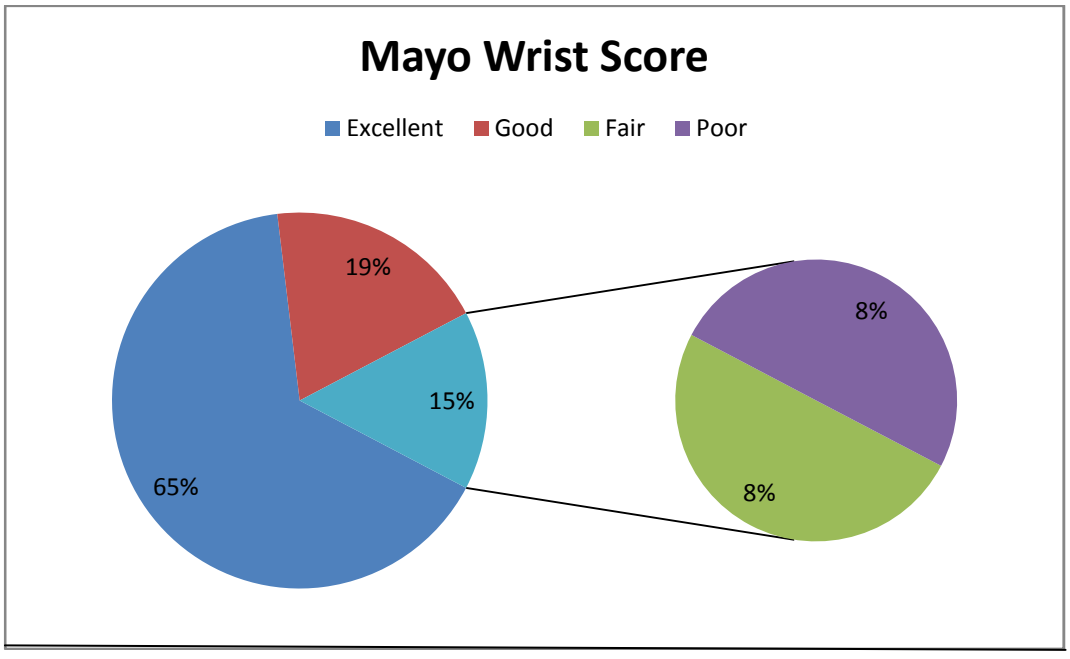
Early radiological evidence of osteoarthosis of the radiocarpal joint on plain radiographs 3 wrist had Grade I osteoarthosis[24].

None of the patients in the present study presented with Iatrogenic Neurovascular injury or Implant breakage or rupture of either flexor nor extensor tendon during the period of follow-up.

## FUNCTIONAL OUTCOME:

### Mayo Wrist Score

| Result | Number of patients |
|---|---|
| Excellent | 17(65%) |
| Good | 5 (19%) |
| Satisfactory | 2 (8%) |
| Poor | 2 (8%) |



# DISCUSSION

The incidence of intra articular distal radius fractures and its complex nature is in increasing trend due to rising road traffic accidents. In our series around 90% of patients are due to RTA and presents with polytrauma, the exact incidence have not been reviewed in the literature. [31,42,43]. In our study 22 of 28 cases (80%) are type C distal radius fractures, which explains the more and more complex presentation of these fracture patterns.

| | **Minimum age in years** | **Maximum age inyears** | **Average age in Years** |
|---|---|---|---|
| Orbay J | 18 | 75 | 59 |
| Jupiter et al | 16 | 76 | 43 |
| Louis Catalano III | 17 | 42 | 30 |
| RE Anakwe | 19 | 56 | 48 |
| Our study | 19 | 70 | 45 |

The average age of 45 years in our study is comparable to Jupiter et al and RE Anakwe who had an average age of 43 & 48 respectively.

Our study had a male preponderance with 26 cases of 28 cases and is comparable to F Fitoussi & SP Chow et al and Orbay J et al which were 92%, 90% and 89% respectively. The higher incidence among the males would be due to higher involvement in road traffic accidents.

In our study left side (non-dominant) was involved in 56% of cases and is comparable to Arora R et al, Louis Catalano et al and Bradway et al's study as 52%, 61% and 54% respectively.

In our study Road traffic accidents dominated with 92%.

| | **RTA (%)** | **Fall on Outstretched Fall** | **Others** |
|---|---|---|---|
| F Fitoussi & SP Chow | 79 | 9 | 12 |
| Jupiter et al | 67 | 33 | - |
| RE Anakwe et al | 10 | 90 | - |
| Chen NC | 70 | 13 | 17 |
| Our study | 92 | 8 | |

This increased nature of RTA violence and involvement of younger age group in our study is a new trend. This could be explained

by fall on outstretched hand in older age causes extra articular fractures with minimal displacement and without involvement of the ulnar side, which were not included in our study.

All in our study belong to either type B or type C of distal radius fractures and graded the severity accordingly. Type C fracture account for 81% in our study which was comparable with Louis Catalano et al 80%[24].

The fixed angled 2.7mm locking plates is the newer choice of implant was used in all our patients, with maximum number of screws in the metaphyseal region in the desired direction of anchorage.

Later many biomechanical and clinical studies were undertaken for knowing the distal radius fixation with placement of locking screws in the metaphyseal bone 5mm close to the distal subchondral bone without violating its articular surface [38]. It became evident that more screw placement in the distal metaphyseal acts as reefing technique.

The importance of the distal ulna is studied after the three column concept was proposed by Rikkliet al[16]. Fixation of the ulnar column was stressed for better function of the wrist and to avoid late distal radio ulnar instability stated by Megan & Belloti et al[31,32] .

Then studies like Douglas Sammer et al stated that stable DRUJ after fixation of distal radius with angle stable volar locking plate needs no further surgical intervention for medial column fracture.

But those with persistent DRUJ instability after distal radius fixation were stabilized by distal radioulnar transfixation K wire for 4 weeks. Vigorous wrist mobilization protocol after transfixation wire removal resulted in good functional outcome even in these group.

In our series 9 cases were presented with co-existent ulnar styloid fracture of which, 7 cases with stable DRUJ was evidenced once radius was fixed with volar LCP. In the remaining 2 cases DRUJ instability was stabilized with additional transfixation K wire for a period of 4 weeks. Removal of these wire after this stipulated period and vigorous wrist mobilization resulted in good functional outcome. The MAYO score in these group presented with 55% of good to excellent functional outcome.

## Co-Existence of Ulnar Styloid Fracture with DRUJ Instability & its Outcome

| Studies | No of patients | # of US | Non union in % | DRUJ instability | Mayo, Good to Excellent |
|---|---|---|---|---|---|
| Phadins et al | 183 | 45% | 32% | 1% | 74% |
| Sammer DM et al | 144 | 61% | 41% | 1% | 52% |
| Kazemian GH etal | 112 | 23% | 11% | 9% | 45% |
| Louis Catalano et al | 21 | 48% | 50% | 21% | 47% |
| Buijze et al | 36 | 100% | 64% | Nil | 64% |
| Our study | 28 | 32% | 10% | 22% | 55% |

The base of the styloid fractures with displacement along the line of the distal radius will be aligned once radial & intermediate column is fixed by definitive fixation & if necessary DRUJ is stabilized with transfixation wire.

The clinical assessment of the distal radioulnar joint becomes difficult in the emergency room setting but it can be assessed under anaesthesia after rigid fixation of the distal radius like piano key test.

Improved biomechanical understandings of the ligaments of the wrist led to the implementation of reefing technique, placement of plate more distally in volar aspect such that screws in the distal metaphyseal fragment will buttress the fragments well and prevent collapse of the articular comminution . [43]

Various studies of fixation for distal radius are coming forth. The newer one is the introduction of variable angle locking screws which as ply of 15*-20* in all direction and also locks with the plate.
The average range of radiological evaluation of various studies was comparable with our study, as tabulated below.

**Radiological Evaluation after Fracture Union**

| Studies | RUI | RL in mm | RI in degrees | VA in degrees |
|---|---|---|---|---|
| Jupiter et al | 65% | 10 | 21 | 7 |
| F.Fitoussi | 43% | 9 | 20 | 3 |
| R E Anakwe | 67% | 11 | 20 | 10 |
| Orbay J et al | 99% | 10 | 21 | 13 |
| Our study | 89% | 10 | 19 | 13 |

The average range of functional outcome of various studies was comparable with our study, as tabulated below.

## Objective Functional Outcome

| Studies | PF in degrees | DF in degrees | Pr in degrees | Sup in degrees | RD in degrees | UD in degrees | GS in degrees |
|---|---|---|---|---|---|---|---|
| Jupiter et al | 66 | 58 | 72 | 78 | 22 | 42 | 71% |
| F.Fitoussi | 52 | 52 | 68 | 88 | 14 | 26 | 76% |
| R E Anakwe | 64 | 62 | 62 | 78 | 20 | 34 | 80% |
| Orbay J etal | 47 | 44 | 77 | 76 | 22 | 32 | 65% |
| Our study | 58 | 56 | 64 | 72 | 24 | 30 | 72% |

Good functional results have been reported with any modality of treatment in low energy fractures in elderly but the ideal treatment for high energy injuries with associated distal ulna fractures is still being debated. The goals of the treatment are anatomical reduction of the distal radius articular surface and achieving distal radio ulnar congruity and early mobilization.

In our study we had 52% of excellent results based on Mayo wrist score and are comparable to other studies as tabulated below.

**MAYO Wrist Score**

| | Excellent | Good | Fair | Poor |
|---|---|---|---|---|
| John K Bradway et al | 44 | 12 | 44 | - |
| Jupiter et al | 63 | 20 | 17 | - |
| Dennison et al | 80 | 20 | - | - |
| Anakwe RE et al | 24 | 60 | 16 | - |
| Our study | 52 | 24 | 16 | 8 |

Complications were minimal and are comparable with standard studies. We had four patients with prominent wires, one case with superficial infection and four patients with wrist and hand stiffness.

In our study two had distal radio ulnar instability identified after stable fixation of distal radius which necessitates additional K wire fixation and immobilization in above elbow slab for 4 weeks. Later it was removed and vigorous wrist mobilization started. The results of these subgroup patients were comparable to studies like Dennison et al.

Primary internal fixation of the distal radius with fixed in variable angle screws of volar locking plate facilitates early mobilization and hence earlier return to activities with good range of movements, especially rotations.

## CONCLUSION

From our study, we conclude that

- Early Primary fixation of the distal radius fractures is essential for good functional outcome and to avoid complication of prolonged immobilization, which facilitates early return to regular activities.
- Patients with unstable, either volar or dorsally displaced fractures of distal radius had excellent or good fuctional outcome when treated with fixed angle volar locking plate.
- With a stable DRUJ after fixation of distal Radius fractures by means of angle stable volar locking plate maintains DRUJ stability. The coexistence of ulnar styloid fracture in these patients did not affect in terms of functional outcome.
- Patients with persistent DRUJ insatiability were stabilized with radioulnar transfixation wire for a period of 4 weeks. Then it was removed and vigorous wrist mobilization resulted in good functional outcome.
- However long term follow-up is needed to further validate our findings.

# CASE ILLUSTRATION -1

## PRE OPERATIVE EVALUATION:

Name: Veeraraghavan

Age/ Sex:55/M

IP No: 93266

Mode of injury: RTA

Time from injury to admission: 5 hrs

Co-morbid illness: Diabetic

Associated injuries: Crush injury Rt lower limb

Muller's classification:C1/Lt side

## SURGICAL EVALUATION:

Time from injury to surgery: 4 days

Time from admission to surgery: 4 days

Duration of surgery: 1hr & 20 min

Position: supine

Anaesthesia: GA

Approach to Radius: Volar Henry

Type of fixation for Radius: Volar LCP

## POST OPERATIVE EVALUATION:

Follow up period: 1 yr & 10 month Mayo wrist score: 90

## Case Illustration 1

Pre-op



Post-op



Intra-op Picture



Follow up: 1yr & 10 mon




# CASE ILLUSTRATION -2

## PRE OPERATIVE EVALUATION:

Name: Ramachandran

Age/ Sex: 28/M

IP No: 100946

Mode of injury: RTA

Time from injury to admission: 24 hrs

Co-morbid illness:-

Associated injuries: Supracondylar femur fracture Rt side

Muller's classification: C3/Lt side

## SURGICAL EVALUATION:

Time from injury to surgery: 3 days

Time from admission to surgery: 2 days

Duration of surgery: 1hr & 10 min

Position: supine

Anaesthesia: RA with SA

Approach to Radius: Extended volar carpal

Type of fixation for Radius : Volar LCP

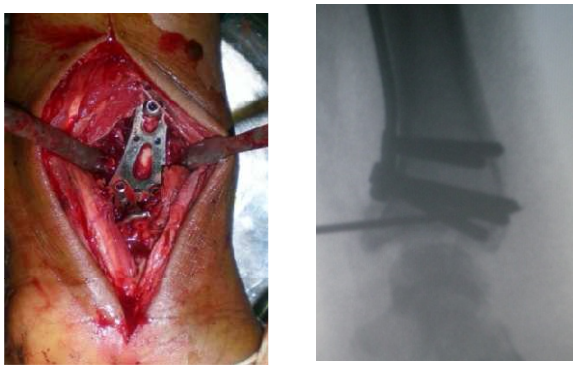
## POST OPERATIVE EVALUATION:

Follow up period: 6 month Mayo wrist score : 80

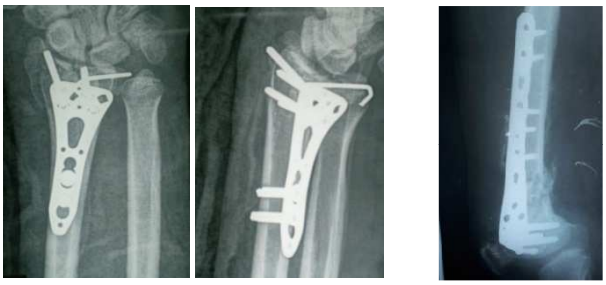
## Case Illustration 2 Ramachandran 28/M

Pre-op


Intra-op



Post-op



Follow-up: 6 month

# CASE ILLUSTRATION -3

## PRE OPERATIVE EVALUATION:

Name: Rajganesh

Age/ Sex: 33/M

IP No:107561

Mode of injury: RTA

Time from injury to admission: 24 hrs

Co-morbid illness:-

Associated injuries: Tibial plateau fracture Rt

Muller's classification:C1/Rt

## SURGICAL EVALUATION:

Time from injury to surgery: 3 days

Time from admission to surgery: 2 days

Duration of surgery: 1 hr & 15 min

Position: supine

Anaesthesia: RA with SA

Approach to Radius: Volar Henry

Type of fixation for Radius; Volar LCP

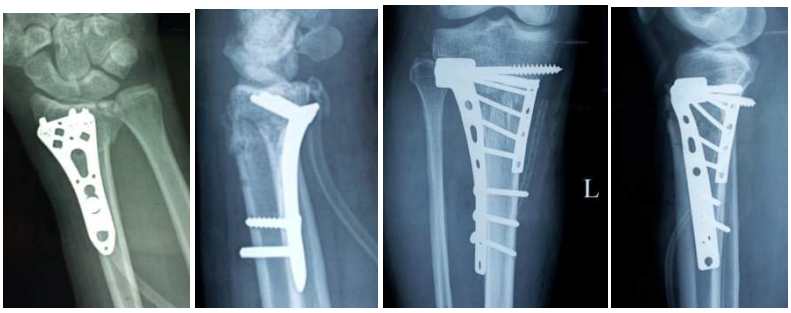
## POST OPERATIVE EVALUATION:

Follow up period: 1 yr Mayo Wrist Score ;90

## Case Illustration 3 Rajganesh / 33/M

Pre-op

Post-op




Follow-up

# CASE ILLUSTRATION -4

## PRE OPERATIVE EVALUATION:

Name: Sivakumar

Age/ Sex: 19/M

IP No: 119166

Mode of injury: RTA

Time from injury to admission: 12 hrs

Co-morbid illness:-

Associated injuries: Supracondylar femur Rt

Muller's classification: C3/Lt

## SURGICAL EVALUATION:

Time from injury to surgery: 2 days

Time from admission to surgery: 2 days

Duration of surgery: 1hr & 10 min

Position: supine

Anaesthesia: GA

Approach to Radius: Extended Volar Carpal

Type of fixation for Radius : Volar LCP

## POST OPERATIVE EVALUATION:

Follow up period: 3 month Mayo wrist score: 80

## Case Illustration 4: Sivakumar/19/M

Pre-op

Post –op


Follow-up

# CASE ILLUSTRATION -5

## PRE OPERATIVE EVALUATION:

Name: Ashok Doss

Age/ Sex: 43/M

IP No:77053

Mode of injury: Self fall

Time from injury to admission: 3 days

Co-morbid illness: Hypertension

Associated injurie:-

Muller's classification: B3/Lt side

## SURGICAL EVALUATION:

Time from injury to surgery: 4days

Time from admission to surgery: 1 day

Duration of surgery: 1 hr

Position: supine

Anaesthesia: RA

Approach to Radius: Volar Henry

Type of fixation for Radius : Volar LCP

## POST OPERATIVE EVALUATION:

Follow up period: 6 weeks Mayo wrist score :75

## Case Illustration 5: AshokDoss /54/M

Pre-op

Post-op

Intra-op picture

Function Demonstration Day 1 Post-op

# CASE ILLUSTRATION -6

## PRE OPERATIVE EVALUATION:

Name: Senthilmurugan

Age/ Sex: 28/M

IP No: 7128

Mode of injury: Fall from height

Time from injury to admission: 12hr

Co-morbid illness:-

Associated injuries: Calcaneum fracture

Muller's classification: C3/Lt side

## SURGICAL EVALUATION:

Time from injury to surgery: 2 days

Time from admission to surgery: 2 days

Duration of surgery: 1hr & 30 min

Position: supine

Anaesthesia: RA

Approach to Radius: Volar Henry

Type of fixation for Radius : Variable Angle LCP

## POST OPERATIVE EVALUATION:

Follow up period: 2 yrs Mayo wrist score :90

## Case Illustration 6:

Pre-op :

Post –op :

Clinical Follow up:

# INTRODUCTION

# AIM OF THE STUDY

# HISTORICAL REVIEW

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# MATERIALS AND METHOS

# OBSERVATIONS

# RESULTS

# COMPLICATIONS

# DISCUSSION

# CONCLUSION

# CASE ILLUSTRATION

# BIBLIOGRAPHY

# ANNEXURE

# BIBLIOGRAPHY


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# PROFORMA

## PRE OPERATIVE EVALUATION:

Name:

Age/ Sex:

IP No:

Mode of injury:

Time from injury to admission:

Co-morbid illness:

Associated injuries:

Muller's classification:

Frykman's classification:

Radiological evaluation on presentation: Palmar tilt

Radial inclination Radial height Deformity

Articular step

CT finding:

## SURGICAL EVALUATION:

Time from injury to surgery:

Time from admission to surgery:

Duration of surgery:

Position:

Anaesthesia:

Approach:

Radius:

Ulna:

Type of fixation:

Radius:

Ulna:

Blood loss:

Post op immobilization (if any):

**POST OPERATIVE EVALUATION:**

Follow up period:

Wound status/ Infection:

Wrist pain:

Distal neuro vascular status:

Union:

Time to union:

Wrist range of motion:

Grip strength:

Radiological evaluation:

Palma tilt:

Radial inclination:

Radial height:

Deformity:

Return to employment:

# INFORMATION SHEET

**Title**: **"A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL & FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE"**

**Principal Investigator:**
**Name of the Participant:**
**Site :**

We are conducting a study on **"A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL & FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE"** among patients attending the Institute of Orthopaedics & Traumatology, Rajiv Gandhi Government General Hospital, Chennai and for that your specimen may be valuable to us.

The purpose of this study is to evaluate and "**A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL, RADIOLOGICAL & FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE**" We are selecting certain cases and if you are found eligible, we may be using your radiographs of the spine to evaluate the outcome of surgery which in any way do not affect your final report or management.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of Investigator Signature of Participant

Date :
Place :

## PATIENT CONSENT FORM

Study Detail : "**A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL & FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE"**

Study Centre : Rajiv Gandhi Government General Hospital, Chennai.
Patient's Name :
Patient's Age :
Identification Number :
Patient may check (√) these boxes

a) I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ❑

b) I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ❑

c) I understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ❑

d) I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms. ❑

e) I understand that my identity will be kept confidential if my data are publicly presented ❑

f) I hereby give permission to undergo detailed clinical examination, Radiographs & blood investigations as required. ❑

g) ) I have had my questions answered to my satisfaction. ❑

h) ) I hereby consent to participate in this study. ❑

Signature/thumb impression

Patient's Name and Address:
Signature of Investigator
Study Investigator's Name:

**Dr.N.Nandakumar**

# Mayo Wrist Score

**Clinician's name (or ref)** _____ **Patient's name (or ref)** _____

Please answer the following 12 multiple choice questions.

**During the past 4 weeks.....**

| **Section 1 - Pain Intensity** |
|---|
| ○ No pain |
| ○ Mild Occasional |
| ○ Moderate, tolerable |
| ○ Severe to intolerable |

| **Section 2 - Functional Status** |
|---|
| ○ Returned to regular employment |
| ○ Restricted employment |
| ○ Able to work, but unemployed |
| ○ Unable to work because of pain |

**Section 3 (choose either 3a or 3b)**

| **3a - Range of Motion (% of normal side)** |
|---|
| ○ 100% |
| ○ 75-99% |
| ○ 50-74% |
| ○ 25-49% |
| ○ 0-24% |

| **3b - If only injured hand examined** |
|---|
| ○ Greater than 120 degrees |
| ○ 90-120 degrees |
| ○ 60-90 degrees |
| ○ 30-60 degrees |
| ○ less than 30 degrees |

| **Section 4 - Grip strength % of normal** |
|---|
| ○ 100% |
| ○ 75-100% |
| ○ 50-75% |
| ○ 25-50% |
| ○ 0-25% |

**The Mayo Wrist Score is** 0

Print page | Close Window | Reset

To save this data please print or Save As CSV

Nb: This page cannot be saved due to patient data protection so please print the filled in form before closing the window.

## Interpreting the Wrist Mayo Score

90-100 Excellent 80-90 Good 60-80 Satisfactory Below 60 Poor

**Reference for Score:** Amadio PC, Berquist TH, Smith DK, Ilstrup DM, Cooney WP 3rd, Linscheid RL. Scaphoid malunion. J Hand Surg [Am]. 1989 Jul;14(4):679-87. Link to pubmed

# INSTITUTIONAL ETHICS COMMITTEE
# MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
Telephone No : 044 25305301
Fax : 044 25363970

## CERTIFICATE OF APPROVAL

To
Dr. N. Nandakumar,
PG in M.S. Orthopaedics,
Institute of Orthopaedics & Traumatology,
Madras Medical College, Chennai-3.

Dear Dr. N. Nandakumar,

The Institutional Ethics Committee of Madras Medical College, reviewed and discussed your application for approval of the proposal entitled **"Analysis of Clinical, Radiological and Functional Outcome of Surgical Management of Type B & Type C Distal Radius fracture with Volar Locking Plate"** No.20102013

The following members of Ethics Committee were present in the meeting held on 08.10.2013 conducted at Madras Medical College, Chennai-3.

| | |
|---|---|
| 1. Dr. G. Sivakumar, MS FICS FAIS | -- Chairperson |
| 2. Prof. R. Nandini, MD<br>Director, Instt. of Pharmacology, MMC, Ch-3 | -- Member Secretary |
| 3. Prof. Ramadevi,<br>Director i/c, Instt. of Biochemistry, Chennai. | -- Member |
| 4. Prof. P. Karkuzhali, MD<br>Prof. Instt. of Pathology, MMC, Ch-3 | -- Member |
| 5. Prof. Kalai Selvi, MD<br>Prof. of Pharmacology, MMC, Ch-3 | -- Member |
| 6. Thiru. S. Govindasamy, BABL | -- Lawyer |
| 7. Tmt. Arnold Saulina, MA MSW | -- Social Scientist |

We approve the proposal to be conducted in its presented form.

Sd/Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information / informed consent and asks to be provided a copy of the final report.

MADRAS MEDICAL COLLEGE * CHENNAI-600 003 * 23 OCT 2013

R Nandini 19/10/13
Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

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*Dissertation submitted to*

**M.S. DEGREE-BRANCH II**
**ORTHOPAEDIC SURGERY**

**THE TAMILNADU DR. M. G. R. MEDICAL UNIVERSITY**
**CHENNAI-TAMILNADU**

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# A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL AND FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE

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| E-mail | drnnkmmc@gmail.com |
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A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL AND FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE Dissertation submitted to M.S. DEGREE-BRANCH II ORTHOPAEDIC SURGERY THE TAMILNADU DR. M. G. R. MEDICAL UNIVERSITY CHENNAI-TAMILNADU APRIL 2014 CERTIFICATE This is to certify that this dissertation titled "A PROSPECTIVE STUDY ON SHORT TERM ANALYSIS OF CLINICAL,RADIOLOGICAL & FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE" is a bonafide record of work done by DR.N.Nandakumar, during the period of his Post graduate study from May 2011 to November 2013...

# MASTER CHART

| S.no | Name | Age | Sex | IP no. | SideOfinjury | Mode ofinjury | AO | Associated injuries | Time delay for surgery in days | Surgical procedure For Radius | Follow up (months) | Radiological findings | | | Mayo wrist score | Functional outcome | Radiological outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Palmar tilt (*) | Radial height (mm) | Radial inclination (*) | | | |
| 1 | kirishnamoorthy | 43 | M | 7616 | L | RTA | B 2 | # shaft of Femur with C5-C6 Sub | 3 | Volar Lcp | 18 | 5 | 10 | 21 | 95 | Excellent | Excellent |
| 2 | Jeevarthinam | 70 | M | 76836 | L | Accidental fall | B 3 | | 14 | Volar Lcp | 3 | 7 | 9 | 17 | 65 | Satisfactory | Fair |
| 3 | Sivaram | 35 | M | 17813 | L | RTA | B 1 | | 1 | Volar Lcp | 17 | 11 | 11 | 23 | 90 | Excellent | Excellent |
| 4 | Bhavankuma | 24 | M | 39178 | L | Fall from height | C3 | # L1 | 2 | Volar Lcp | 2 | 8 | 7 | 17 | 75 | Good | |
| 5 | Arumugam | 38 | M | 10985 | L | RTA | B2 | # BB leg | 4 | Volar Lcp | 1 | 5 | 11 | 21 | 90 | Excellent | Excellent |
| 6 | Murugan | 56 | M | 29176 | R | RTA | B 3 | # L3 | 3 | Volar Lcp | 11 | 8 | 11 | 23 | 95 | Excellent | Excellent |
| 7 | Balaji | 25 | M | 48173 | R | RTA | C1 | # shaft of femur | 3 | Volar Lcp | 12 | 5 | 10 | 22 | 95 | Excellent | Excellent |
| 8 | Mathialagan | 55 | M | 47942 | R | RTA | C3 | # olecranon | 1 | Volar Lcp | 3 | 5 | 6 | 11 | 45 | Poor | Poor |
| 9 | Mohandas | 19 | M | 64217 | R | RTA | C2 | Crush injury lt arm | 1 | Volar Lcp | 9 | 10 | 10 | 22 | 95 | Excellent | Excellent |
| 10 | Velu | 20 | M | 64232 | L | RTA | C 2 | # shaft of femur | 1 | Volar Lcp | 18 | 0 | 5 | 20 | 45 | Poor | Poor |
| 11 | Ramachandra | 52 | M | 78825 | L | RTA | B1 | # shaft of femur | 2 | Volar Lcp | 12 | 0 | 10 | 20 | 95 | Excellent | Excellent |
| 12 | Kandasamy | 55 | M | 64917 | L | RTA | C3 | # L1 with # BBleg | 2 | Volar Lcp | 9 | 0 | 6 | 10 | 65 | Satisfactory | Excellent |
| 13 | Sivakumar | 21 | M | 65780 | R | RTA | B3 | # SC femur | 2 | Volar Lcp | 9 | 8 | 10 | 20 | 85 | Good | Good |
| 14 | Veeraraghavan | 55 | M | 85624 | B/L | RTA | C2 | Crush injury rt leg | 4 | Volar Lcp | 8 | 5 | 8 | 20 | 85 | Good | Excellent |
| *15* | *Devarj* | *47* | *M* | *97203* | *L* | *RTA* | *C3* | | *1* | *Volar Lcp* | *8* | *8* | *10* | *15* | *80* | *Good* | *Good* |

| S.no | Name | Age | Sex | IP no. | SideOfinjury | Mode ofinjury | AO | Associated injuries | Time delay for surgery in days | Surgical procedure For Radius | Follow up (months) | Radiological findings | | | Mayo wrist score | Functional outcome | Radiological outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Palmar tilt (*) | Radial height (mm) | Radial inclination (*) | | | |
| 16 | Senthil murugan | 33 | M | 17616 | L | RTA | C 2 | Calcaneal # with # scaphoid | 4 | Volar Lcp | 6 | 12 | 10 | 21 | 85 | Excellent | Excellent |
| 17 | Rajganesn | 32 | M | 58836 | L | RTA | C 3 | # Tibial plateau | 2 | Volar Lcp | 4 | 10 | 9 | 20 | 85 | | |
| 18 | Ashok Doss | 45 | M | 63813 | L | RTA | C 1 | | 4 | Volar Lcp | 6 wks | 11 | 11 | 22 | 90 | Excellent | Excellent |
| 19 | Malliga | 24 | F | 91457 | L | Fall from height | C3 | # L1 | 2 | Volar Lcp | 2 | 7 | 6 | 15 | 70 | Good | Good |
| 20 | Prakash | 38 | M | 29874 | R | RTA | B3 | # proximal humerus | 3 | Volar Lcp | 7 | 9 | 10 | 21 | 90 | Excellent | Excellent |
| 21 | Manikandan | 46 | M | 76465 | R | RTA | C 3 | | 4 | Volar Lcp | 15 | 8 | 11 | 18 | 95 | Excellent | Excellent |
| 22 | Balaji | 20 | M | 48187 | R | RTA | C1 | # SC femur | 17 | Volar Lcp | 13 | 8 | 10 | 22 | 75 | Good | Good |
| 23 | Rathi | 55 | F | 65742 | R | RTA | C3 | | 12 | Volar Lcp | 3 | 6 | 6 | 14 | 55 | | |
| 24 | Naagrswaran | 49 | M | 56317 | B/L | RTA | C3 | B/L distal radius | 3 | Volar Lcp | 10 | 10 | 10 | 21 | 75 | Good | Good |
| 25 | Kennady | 58 | M | 23768 | L | RTA | C 2 | Compartment syndrome | 1 | Volar Lcp | 12 | 11 | 9 | 21 | 55 | Poor | Good |
| 26 | Hemasai | 52 | M | 26387 | L | RTA | C2 | | 2 | Volar Lcp | 3 | 10 | 10 | 20 | 85 | Excellent | Excellent |
| 27 | Munusamy l | 65 | M | 41098 | L | Accidental fall | C1 | | 2 | Volar Lcp | 6 | 10 | 7 | 15 | 85 | Satisfactory | Excellent |
| 28 | Karupasamy | 51 | M | 65718 | R | RTA | C1 | | 2 | Volar Lcp | 8 | 8 | 10 | 20 | 80 | Good | Excellent |